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ELEMENTS OF NATURAL HISTORY, AND OF CHEMISTRY:

BEING THE SECOND EDITION OF

THE ELEMENTARY LECTURES ON THOSE SCIENCES,

FIRST PUBLISHED IN 1782,

AND NOW

GREATLY ENLARGED AND IMPROVED,

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ELEMENTS
OF
NATURAL HISTORY,
AND OF
CHEMISTRY.

PART III.

The Vegetable Kingdom.

CHAP. I.

Concerning the Structure of Vegetables.

VEGETABLES are organized bodies, fixed at the ſurface of the earth, and poſſeſſing neither ſenſibility nor ſpontaneous motion. They are diſtinguiſhed by their external appearance and conſtruction, and differ more particularly from minerals, in the circum-

ſtance of their being nouriſhed by introſuſception, and their elaborating the juices deſigned to increaſe their bulk. They preſent phenomena, which depend on their organization, and are called functions; the principal of which is, their reproduction, by means of ſeed, or eggs, like animals.

Vegetables differ from each other, 1. By their magnitude: they are diſtinguiſhed into trees, ſhrubs, herbs, moſſes, &c. 2. By their places of growth: ſome grow in dry, and others in moiſt grounds; others in ſand, clay, water, on the ſurface of ſtones, or on other vegetables, &c. 3. By their ſmell, taſte, colour, &c. 4. By their duration: plants are perennial, annual, biennial, &c. 5. By their uſe, either as food, medicine, &c. A great number are uſed in the arts, ſuch as dying, &c. others are uſed merely for pleaſure, ornament, &c.

Vegetables, externally conſidered, are formed of ſix parts, or organs, deſtined to perform peculiar functions. Theſe parts are the root, the ſtem, the leaf, the flower, the fruit, and the ſeed. Theſe differ in form, texture, magnitude, number, colour, duration, taſte, &c.

1. The root is concealed in the earth, in water, or in the bark of other vegetables. It is either tuberous, or fibrous, or bulbous. Its direction is either perpendicular, or horizontal; and its conſiſtence, as well as its form,

form, is ſubject to great variations. Botaniſts diſtinguiſh them into ſeveral ſpecies, and avail themſelves of theſe diſtinctions, as ſpecific characters.

2. The ſtem grows out of the root, and ſuſtains the other parts. It is either ſolid, or hollow, ligneous or herbaceous, round, ſquare, triangular, or having two acute angles, &c. The ſtem comprehends the wood and the bark. The wood is diſtinguiſhed into wood, properly ſo called, and ſap. The bark conſiſts of the epidermis, the pulp or veſicular part, and the cortical ſtrata, or inner rind. The ſtem is divided into branches, which have abſolutely the ſame ſtructure; and the diverſity of this part very often ſerves to eſtabliſh the diſtinctive characters of the ſpecies and varieties.

3. The leaves of vegetables are exceedingly varied. A By their form: they are oval, round, ſagitated, haſtate, oblong, eliptic, cuneiform, &c. B By their poſition on their ſtem: they are either ſeſſile, petiolate, oppoſite, alternate, ſtellate, perfoliate, vaginant, &c. C By their margin: they are either uniform, dentate, crenate, ſerrate, repand, undulated, lacerated, truncated, &c. D By their ſimplicity or compoſition: compound leaves are formed, by the inſertion of foliolæ, or leſſer leaves, and are then either digitate or conjugate, with either an odd or an even number of leaves.

leaves. E By their poſition or place: they are radical, cauline, or floral. F By their colour, ſmell, taſte, conſiſtence, &c. Their uſe appears to conſiſt in abſorbing the elaſtic fluids of the atmoſphere, and exhaling different kinds of air, according to circumſtances.

4. The flowers are parts deſigned to contain the organs of generation, and defend them till the fecundation is accompliſhed, at which time they fall. The flower is diſtinguiſhed into two parts: the external part ſerves to incloſe and protect the internal part, whoſe uſe conſiſts in reproducing the plant. The former comprehends the calyx, and the corolla. The calyx is external, and green. Linnæus diſtinguiſhes it into ſeven ſpecies; namely, the perianthium; the ſpartha, or ſheath; the huſk; the involucrum; the amentum, or catkin; the calyptra, or veil; and the volva. The corolla is the coloured part commonly called the flower; it is either monopetalous, or conſiſting of one ſingle piece; or polypetalous, conſiſting of ſeveral parts. The ſyſtem of Tournefort is founded on the corolla. The parts of the corolla are called petals. The organs included, and often concealed in plants, are the ſtamina, and the piſtils or ſtyles. The ſtamina are the male, or fecundating parts, and are almoſt always more numerous than the piſtils. They conſiſt of the filament,

and

and the anthera. This laſt, placed at the extremity of the filament, is a ſmall bag, containing the fecundating powder. The piſtil is in the midſt of the ſtamina: it is ſometimes on another flower, or even on another plant; which circumſtance occaſions the diſtinction of plants into male and female. The piſtil conſiſts of three parts; the inferior part, which contains the embryo, and is called, in Latin, germen; the filament, which grows out of the inferior part, and is called the ſtyle; and its extremity, which is more or leſs dilated, is called ſtigma. The ſexual ſyſtem of Linnæus is founded on the number and poſition of the ſtamina and piſtils. Mr. De Juſſieu has eſtabliſhed a ſyſtem, founded on the inſertion of the ſtamina above or below the germen, &c.

5. Flowers are ſucceeded by fruits. Botaniſts diſtinguiſh ſeven ſpecies; the capſule, the ſiliqua, the legumen, the conceptaculum, which becomes dry; fruits having kernels, fruits having pippins and berries, which remain ſucculent. Theſe organs are deſigned to incloſe the ſeeds, and defend them from external agents.

6. The ſeed differs greatly in its form, magnitude, appendices, &c. It contains the plumula, or ſmall plant; the radicula, and the cotyledons. Theſe laſt are two in number in moſt vegetables; but many families of plants have no more than one cotyledon.

tyledon. This part is to the grain, what the yellow and white of the egg is to the embryo bird; it contains a proper nouriſhment for the individual during the germination.

Vegetables, conſidered with reſpect to their internal parts, preſent five ſpecies of veſſels, or organs, which exiſt in all their parts; 1. The common veſſels, which conduct the ſap: they are placed in the central part of plants and trees, and riſe perpendicularly, though with lateral bendings, ſo as to form ſmall vacancies between them. 2. The proper veſſels, which convey the juices peculiar to each vegetable, ſuch as the oils, gums, reſins, &c. They are placed beneath the bark, and appear in many places to be dilated into cavities, or reſervoirs, which ſeem to be the excretory veſſels. 3. The tracheæ, or veſſels through which air circulates: when a young green branch is torn aſunder, they may be obſerved of a ſpiral form, reſembling a cork-ſcrew. They are often filled with ſap. 4. The utricles, or ſmall veſſels, which contain a ſecreted juice, and frequently colouring matter. They are placed in the middle of the ſtem. 5. The veſicular tiſſue, which exhibits a ſeries of ſmall cells, which leading horizontally from the pith, and croſſing the ſap veſſels, and filling the vacuities between them, are expanded beneath the epidermis, form a kind of ſoft covering, reſembling the ſkins of animals.

The

The veſicular tiſſue of vegetables appears to anſwer to the cellular membrane of animals.

All the parts of vegetables conſiſt of an aſſemblage of theſe five kinds of veſſels, each in particular being more or leſs numerous, dilated, contracted, &c. The differences in the form and texture of roots, ſtems, leaves, &c. depend on this diverſity of number and diſpoſition.

Malpighi, Grew, and Duhamel, have been the moſt ſucceſsful in their reſearches into the natural hiſtory of plants, and their works are the moſt inſtructive, with reſpect to the internal formation of their ſeveral parts.

CHAP. II.

The Natural Philoſophy of Vegetables.

THE organs of vegetables, which we have conciſely deſcried in the foregoing chapter, are deſigned to perform ſeveral motions, which are called functions. Theſe functions are,

1. The motion, or circulation of the fluids.
2. The alterations, or change of theſe fluids, by ſecretion.

3. The augmentation and developement of the vegetable by nutrition.
4. The exhalation of different fluids elaborated in the organs of vegetables, and the inhaling of ſeveral principles contained in the atmoſphere, by the ſame organs.
5. The action of the air, and the uſe of this fluid in the veſſels of vegetables.
6. The motion performed by ſome of their parts.
7. The kind of ſenſibility by which they endeavour to obtain the contact of ſuch bodies as tend to promote the functions, ſuch as light, &c.
8. And laſtly, The various phenomena which ſerve to reproduce the ſpecies, and conſtitute the generation of plants. We ſhall conſider each of theſe functions ſeparately.

The principal fluid of vegetables, which is known by the name of ſap, is contained in peculiar veſſels, called the common veſſels. Theſe veſſels, which are placed in the middle of the ſtem, and beneath the bark, are extended from the root to the leaves and flowers. The ſap which they conduct, is a colourleſs fluid, of an inſipid taſte, and, like the blood in animals, becomes ſeparated into different juices, for the nouriſhment and ſupport of the ſeveral organs. It is very abundant

dant in the ſpring, its preſence being then ſhewn by the production of leaves and flowers. All the phenomena of vegetation, as well as experiments made by applying ligatures about plants, ſhew, that it riſes from the root to the ſtem and branches. But it is not ſo well aſcertained, that it deſcends again towards the root, as ſome philoſophers have affirmed. The valves admitted to exiſt, by many botaniſts, in the common veſſels, have not been exhibited; unleſs we may call by this name certain fibres, or hairs, with which their internal parts appeared to be lined, according to Tournefort and Duhamel. Their regular motion of this fluid is very far from reſembling the circulation in animals.

The ſap, when conveyed into the utricles, and thence into the proper veſſels, is elaborated in a peculiar manner: it produces different ſaccharine, oily, mucilaginous fluids, which are emitted in conſequence of an organic proceſs, and whoſe evacuation ſeems to be an advantage to the vegetable, ſince it does not receive any damage from a very conſiderable occaſional loſs of thoſe matters. This alteration of the fluids, which is very obſervable in many organs, as in the nectarium, at the extremity of the piſtil, in the pulp of fruits, at the baſe of the calyces, and of many leaves, is produced intirely by that function, which in animals is called ſecretion.

tion. Guettard has carried this analogy ſo far, as to deſcribe glands of various forms at the baſes of the leaves of fruit trees, and towards the inner extremity of the petals of certain flowers. It is this ſecretion which developes the principle of ſmell, the colouring matter, the combuſtible ſubſtance, &c. But it differs very eſſentially from animal ſecretion, which is intirely produced by the organization of the glands, which elaborate the animal fluids; whereas, in vegetables, the juices contained in the common veſſels are more expoſed to the contact of air, light, and the action of heat; and their ſituation renders them capable of paſſing through the proceſſes of fermentation by means of theſe agents.

The ſap, while it remains in the cavities of the utricles, and of the veſicular tunic, becomes thick, and more conſiſtent. This alteration renders it capable of adhering to the ſides of the fibres, and of gradually augmenting their dimenſions. Such is the mechaniſm of the nutrition of vegetables, their increaſe of magnitude, and the developement of their parts. It greatly reſembles the nutrition of animals. The veſicular tunic, and the utricles, have the ſame conformation, and the ſame uſe in both claſſes of organized beings. In both, they penetrate all their organs, eſtabliſhing an immediate commu- nication

nication between them, and in both they are the true ſeat of nutrition.

Philoſophical botaniſts have long been convinced, that exhalations are emitted into the air from the ſurfaces of plants. The odoriferous exhalation of leaves and flowers forms an atmoſphere around vegetables, which ſtrikes our ſenſes, and which the contact of a body on fire is ſometimes capable of inflaming, as has been obſerved with regard to the fraxinella. This exhalation appears to be a peculiar kind of inflammable gas. Experience has likewiſe ſhewn, that many vegetables emit vapours which are mortal to ſuch animals as remain long expoſed to them. Such are the yew, and many trees, natives of hot countries. The experiments of Mr. Ingenhouſz have ſhewn, that the leaves of all plants expoſed to the light of the ſun emit an inviſible fluid, which conſiſts of true vital air, ſimilar to that which is obtained from calces of mercury, &c. This property of leaves is intirely changed in the ſhade, in which ſituation they emit the cretaceous acid. This happy diſcovery, firſt publiſhed by Dr. Prieſtley, ſhews an unſuſpected property in plants, namely, that of purifying and renewing the air, by reſtoring that portion of vivifying fluid which is continually deſtroyed by combuſtion, reſpiration, &c. But at the ſame time that vegetables continually emit vaporous

rous fluids produced in the laſt proceſſes of vegetation, they likewiſe abſorb many of the principles contained in the atmoſphere. The lower ſurface of leaves abſorbs the humidity of the dew, according to the experiments of Bonnet. Dr. Prieſtley's experiments likewiſe prove, that vegetables abſorb the gaſes, which remain after combuſtion and reſpiration, and that vegetation is ſtronger in air changed by theſe proceſſes. The exhalation and inhalation at the ſurface of vegetables are conſequently much more conſiderable than was ſuppoſed before the time of the modern diſcoveries. It even appears that the water abſorbed by the inferior ſurface of leaves is decompoſed; that the baſe of inflammable air it contains is abſorbed; and that the pure air diſengaged from the ſuperior ſurface of the leaves is produced by the oxyginous principle contained in that fluid. The contact of the rays of the ſun contributes greatly to this decompoſition, as it does not take place in the ſhade. Plants defended from the action of light, abſorb water intirely without decompoſition, and become white, inſipid, and ſoft; a much leſs quantity of coloured, combuſtible, or oily matter, being formed.

The gaſes abſorbed by vegetables, are conveyed into all their organs by the air veſſels, which in their uſe and ſtructure reſemble thoſe of inſects and worms. The air veſ-

ſels

ſels are not, however, appropriated ſolely to the circulation of elaſtic fluids; for they are obſerved to be filled with ſap, at thoſe times of the year in which that fluid is moſt abundant: a circumſtance which conſtitutes a great difference between them and the organs of reſpiration, ſo eſſential to the exiſtence of a great number of animals. From the theory of reſpiration, which we have explained in the hiſtory of air, it is eaſy to ſhew why the temperature of vegetables does not exceed that of the air which ſurrounds them.

It cannot be doubted, but that many parts of vegetables have an internal principle of motion; in ſome it is ſo evident, as to be moſt obviouſly diſtinguiſhed. Such is the motion of the ſenſitive plant, of the ſtamina of the Indian fig, of pellitory, &c. This motion ſeems to depend on the function, which is known in animals by the name of irritability; for it is excited by the action of a ſtimulus, and has peculiar organs, which ſome botaniſts have compared to muſcular fibres.

Ought we not to admit a ſort of ſenſibility in plants, when we obſerve them to turn their leaves and flowers towards the ſun, and when we obſerve that plants, incloſed in wooden boxes, glazed on one ſide, perforated, or merely thinner on one ſide than the others, conſtantly tend towards the tranſ-

tranſparent body, or the aperture through which the light paſſes, or even towards the ſide, which by its leſs thickneſs may admit a glimmering light? Or may we not attribute this apparent ſenſibility to the force of affinity, or tendency to combination, which exiſts between vegetables with light? It is well eſtabliſhed, that this fluid, either by percuſſion or combination, aſſiſts in producing the colour, taſte, and combuſtible property in plants; becauſe plants, which grow in the ſhade, are white, inſipid, aqueous, and contain no inflammable matter; whereas vegetables expoſed, in the burning climates of the ſouth, to the ſtrong rays of the ſun, become highly coloured, abound with bitter and reſinous parts, and are eminently combuſtible. However ſtrong we may ſuppoſe this affinity to be, we cannot conceive how it ſhould be capable of exciting a motion ſo conſiderable in the branches and leaves of vegetables. We muſt therefore neceſſarily admit a peculiar kind of ſenſation, or feeling, very different, it is true, from the ſenſes of animals, by means of which vegetables give a preference to ſuch ſituations as are moſt acceſſible to light.

The manner in which the ſpecies are produced, among vegetables, greatly reſembles the generation of animals. The exiſtence and union of ſexes are neceſſary in the greateſt number of plants. The labours of the celebrated

celebrated Linnæus have diſcovered a ſtrong analogy between the organs deſtined for this function in the two claſſes of organic beings. The ſtamina correſpond with thoſe of the male ſex, and the piſtil is compoſed of three parts, analagous to thoſe of the genitals of female animals. The embryo is developed, by the action of the fecundating powder, without which it is not capable of producing an individual, as is likewiſe daily obſerved among birds. But beſides this analogy, which need not be further purſued, vegetables are of a much ſimpler ſtructure than animals; and all their parts being compoſed of the ſame organs, each is capable of producing a new individual ſimilar to itſelf. This is the reaſon of the reproduction of plants, by means of ſcions or ſlips, as well as the alteration of the fluids, by grafting, whether natural or artificial. There is likewiſe another analogy, of modern diſcovery, between vegetables and that claſs of animals which is reproduced, by diviſion into pieces, as the polypus, cruſtaceous inſects, certain worms, &c.

All the functions, which, taken together, conſtitute the reſemblance between vegetables and animals, are ſuſceptible of alterations, which produce diſorders. Theſe depend, moſt commonly, on the abundance or defect of the ſap, as well as its bad qualities, and are analogous to thoſe which take place

place in animals. Their cauſes, ſymptoms, and cure, are alike referable to the general principles of medicine, and form a part of agriculture, which it muſt be confeſſed is not much advanced, but capable of great improvement, according to the plans of ſeveral celebrated authors.

CHAP. III.

Concerning Juices and Extracts.

THE fluids contained in vegetables, are of two kinds; the common, and the proper juices. The firſt, conſiſts of the ſap which is found in all plants. It is contained in the common veſſels, flows naturally out of their ſurface, but is more abundantly extracted by inciſion. The ſap is not merely an aqueous fluid, but contains ſalts, extracts, and mucilages. When a certain quantity is deſired, either for medical uſe, or philoſophical inquiry, the plant is beat in a mortar, and preſſed in a cloth, beneath a preſs, if neceſſary.

Succulent vegetables give out their juice by ſimple expreſſion; but thoſe whoſe juices are viſcous, or in ſmall quantity, require to be diluted with water, ſuch as borage, and the

the dry aromatic plants. This fluid being extracted, by ſtrong preſſure, is found to contain a portion of the ſolids of the vegetables beaten ſmall by the peſtle, and conſequently requires depuration; which may be effected either, A By ſubſidence, or filtration, when they are very fluid, as is the caſe with the juice of purſlain, houſeleek, &c. B By white of egg, which collects the fecula, by coagulation, as is requiſite with the juice of borage, nettle, &c. C By ſimple heat, which coagulates and precipitates the parenchyma, as Mr. Baumé adviſes, with reſpect to juices that contain volatile principles, ſuch as thoſe of cochlearia, creſſes, &c. The phial which contains the juice, being covered with a perforated paper, muſt be plunged in boiling water, and taken out as ſoon as the juice is clarified. Immerſion in cold water brings it to a proper temperature for filtration; D By ſpirit of wine, which coagulates the fecula; E By vegetable acids, as the London Pharmacopeia preſcribes for the juices of cruciform plants.

The juices of plants hold in ſolution matters which, when ſeparated from the aqueous vehicle, form what, in pharmacy, are called extracts. Theſe are diſtinguiſhed into three kinds; mucilaginous, ſaponaceous, and gum-reſinous extracts.

Mucilaginous extracts, are ſuch as readily diſſolve in water, ſcarcely at all in ſpirits of

 wine,

wine, and undergo ſpirituous fermentation: ſuch is the rob of gooſeberries, prepared by evaporating the juice of that fruit.

Saponaceous extracts are diſtinguiſhed by ſolubility in water, and partly in ſpirit of wine; they become mouldy, inſtead of paſſing to the ſpirituous fermentation. The juice of borage, when converted into an extract, is of this nature; and theſe are extracts properly ſo called.

Gum reſins diſſolve in water, and in ardent ſpirit; they are inflammable, by virtue of the reſinous principle they contain, and are not changed by expoſure to air. The concentrated juice of wild cucumber, called elaterium is of this kind. Inciſions are made in the fruit; and the expreſſed juice being ſuffered to clarify, by repoſe, is evaporated to dryneſs on the water bath.

Extracts of theſe three different ſpecies are prepared, in the large way, by evaporating the juices of ſeveral plants. Such, among others, are,

1. The juice of acacia, imported from Egypt, where the fruit of this tree is maſhed, preſſed, and the juice expoſed to evaporation by the ſun's heat. The inſpiſſated juice of ſloes is prepared, in Germany, by a ſimilar proceſs, and ſold under the ſame denomination.

2. That of hypociſtis, which is made like the

the foregoing, with the fruits of this parasitical plant.

3. Opium, an important medicine, whose nature is not accurately known. It is extracted from the white poppy, in Persia, &c. where it flows through incisions made in the green capsules of the plant, in the form of a white juice, which dries into brown tears of the true opium. The opium of commerce is obtained, by pressure, from these capsules, moistened with water, and comes to us in a dry form, in flat circular cakes, wrapped up in leaves, and mixed with many impurities. It is purified by solution in as small a quantity of water, as is sufficient to suspend it; which being filtered, or strained by strong pressure, is evaporated on the water bath. This is the extract of opium, and contains a saponaceous extract, a solid essential oil, an odorous, noxious, and narcotic principle, an essential salt, and a glutinous matter. As the odorant, poisonous and narcotic principle, is often productive of bad effects, attempts have been made to obtain an extract of opium, deprived of this principle. Mr. Baumé, who has made many experiments on opium, volatilized this principle, together with the essential oil, and by that means separated the resin, after a digestion of six months. Bucquet has discovered, that the same sedative extract, without the narcotic property, may be obtained

 by

by diſſolving opium in cold water, and evaporating the ſolution in a water bath. Lorry, who has made ſucceſsful inquiries into this ſubject, finds, that opium, after fermentation, affords a diſtilled water, which has the ſedative property, without producing the bad effects of the crude ſubſtance, and which he has uſed with great ſucceſs. He obſerves, that the odorous principle of this medicine cannot be deſtroyed by any proceſs.

When the plants, from which it is propoſed to make extracts, are dry and ligneous, maceration, infuſion, or decoction in water, are employed, according to the ſtate and nature of the materials: maceration is, in moſt caſes, ſufficient. Odoriferous plants muſt be only infuſed; decoction extracts too much, and ſeparates the reſinous parts, forming a thick fluid, which becomes turbid on cooling. Infuſion may be uſed, in all caſes, according to the opinion of the moſt celebrated phyſicians and chemiſts.

Water extracts various products from ſeveral plants. Thus the berries of juniper afford a mucilaginous extract; quinquina affords a ſaponaceous extract, in ſmall tranſparent ſcales, reſembling ſalts, if the evaporation be made in very ſhallow veſſels; and rhubarb affords a gummy reſinous ſubſtance.

The ſaponaceous, or more properly the chemical

chemical extract, appears to be a compound of oil and fixed vegetable alkali. The extracts, prepared in pharmacy, are very far from being all of the ſame nature; they are mixed with mucilage, eſſential ſalt, ſaccharine juice, reſin, &c. From theſe conſiderations, Rouelle, with the intention of illuſtrating this part of medical chemiſtry, diſtinguiſhed them into the three genera we have mentioned: but the pure extract, reckoned among the immediate principles of vegetables, muſt be conſidered as a ſaponaceous compound, poſſeſſing peculiar properties.

Extracts are prepared in the large way, in commerce, by means of water. Such as,

1. The yellow juice of liquorice, by the firſt infuſion, or black, by ſtrong decoction. This laſt is burned, and contains a true charcoal. It is purified by ſolution in water, filtration, and evaporation, uſually with the addition of ſome eſſential aromatic oil of anniſeed, cinnamon, &c.

2. The cachou, or, as it is improperly called, Japan, earth, is prepared in the Eaſt Indies, from the infuſion of the ſeeds of a kind of palm, called areca, the infuſion being evaporated, and made into cakes. It is purified by ſolution in water, and evaporation, uſually with the addition of aromatics.

Among the extracts prepared for medical uſe, Rouelle particularly diſtinguiſhed thoſe

which are mixed with resin, by the names of gum resins, and resinous extracts.

Gum resins do not burn without being first dried, and appear to contain a larger quantity of extract, properly so called, than of resin. The resinous extract burns much better, and appears to contain more resin, than extractive matter. This happy distinction shews, that the two species consist simply of mixtures of extract with different doses of the resinous principle. They are not, therefore, with propriety called extracts, that name being applicable only to the saponaceous matter, whose properties we shall proceed to enumerate.

The pure extract differs from the foregoing: it is a dry, solid, brownish red, transparent substance, which does not burn by itself, but emits plentiful fumes, and contains more or less essential salt. Its taste is almost always bitter; by distillation, it affords an insipid phlegm; this phlegm, by a mild heat, becomes gradually of a deeper colour, and assumes alkaline properties, as is observable with elaterium, extract of borage, &c. The volatile alkali is formed by the heat; a small quantity of empyreumatic oil next comes over; and the coaly residue, which is light and porous, contains alkali, and almost always neutral salt. The extract, exposed to air, becomes mouldy, and attracts moisture; the salt it contains crystallizing,

and

and ſeparating from the extractive part. They are often changed, and intirely decompoſed. It diſſolves in water; producing the appearance of a ſtrong infuſion. Acids decompoſe this ſolution, in the ſame manner as they do ſoaps, and diſengage a principle more or leſs oleaginous. Metallic ſolutions likewiſe ſeparate this principle, by double affinity. The chemical properties of extract have not been farther examined into; but thoſe that are already known, evince, that it is with great propriety conſidered as a kind of ſoap.

Extracts are uſed in medicine as aperitive, ſolvent, diuretic, ſtomachic, remedies, and are daily adminiſtered with great ſucceſs.

CHAP. IV.

Eſſential Salts.

THE ſaline ſubſtances, held in ſolution in the juices of plants or the water wherein they are infuſed, are called eſſential ſalts of plants. They are obtained by cooling thoſe fluids, which are firſt evaporated to the conſiſtence of ſyrup. As theſe ſalts are impregnated with extractive, and fat matter, it is neceſſary to purify them with lime and

whites of eggs. If theſe ſalts be of an acid nature, lime muſt not be uſed, becauſe it would neutralize them, but pure white clay in powder. After the firſt extraction, they are ſtill very impure. Solution in diſtilled water, and cryſtallization, may be repeated till they become pure and white.

The eſſential ſalts of plants are of a different nature, and may be diſtinguiſhed into two claſſes.

Class I. Of Eſſential Salts.

The firſt claſs includes thoſe which reſemble mineral ſalts. The principal ſpecies are, 1. Cretaceous fixed alkalis, which are obtained from almoſt all plants, by macerating them with acids, as Margraff and Rouelle the younger have ſhewn. The vegetable alkali is the moſt common, but the mineral alkali exiſts in marine plants. 2. Vitriolated tartar, or vitriol of pot-aſh, in millefoil, in aſtringent and aromatic plants, in ſpurge flax, and in the mark of olives. 3. Glauber's ſalt, or vitriol of ſoda, from tamariſk. 4. Nitre, from borage, turnſole, tobacco, &c. 5. The febrifuge ſalt of Sylvius, or muriate of pot-aſh; and marine ſalt, or muriate of ſoda, in marine plants. 6. Selenite diſcovered by Model in rhubarb.

Many other ſalts will doubtleſs be found, reſembling thoſe of minerals, when a greater number

number of plants ſhall be accurately analyzed. It has likewiſe been thought that volatile alkali; or rather ammoniacal chalk, exiſts ready formed in cruciferous plants; becauſe theſe plants, by diſtillation, afford on the firſt application of heat, a phlegm which holds a ſmall quantity of that ſalt in ſolution. On this account the ancients called them animal plants; but Rouelle the younger has ſhewn, that this ſalt does not exiſt ready formed in plants, but is produced by the re-action of the principles, which is promoted by heat. Mr. Baumé pretended that the volatile principle of cruciferous plants is nothing but ſulphur. The volatile alkali obtained from theſe plants, ariſes from the inflammable gas of the oil united to the mephitis contained in the vegetable, as Mr. Berthollet has ſhewn.

Various opinions have been held, reſpecting the mineral ſalts found in plants. Some have thought, that theſe ſalts were conducted from the earth by water, and paſſed into the vegetables without alteration. Others have ſuppoſed, that the ſaline ſubſtances were formed by the proceſs of vegetation. It is certain, that two very different plants growing in the ſame ſoil, as for example, borage and millefoil, afford each the ſalt peculiar to itſelf; that is to ſay, the borage affords nitre, and the millefoil vitriolated tartar. A ſingle experiment, which has been much talked

talked of, but never accurately made, would decide the queſtion; namely, to cauſe ſuch plants as afford a certain ſalt, for example, nitre, to grow in a quantity of earth, previouſly lixiviated, and to water them with water containing marine or ſome other ſalt. If the plants in theſe circumſtances afford nitre, and not marine ſalt, it might be concluded that the ſalt does not paſs as ſuch into the organs of plants, and that the proper ſalt is formed by the proceſs of vegetation.

Class II. Of Eſſential Salts.

The ſecond claſs contains ſuch ſalts as are peculiar to vegetables. Theſe truly eſſential ſalts always conſiſt of an acid united with an alkali, or an oil. The acid is often in a diſengaged ſtate, though ſometimes maſked by other ſubſtances.

The eſſential acid ſalts of vegetables are found in a great number of plants, and are afforded, in general, by all thoſe which have a ſour taſte. Such are ſorrel, acid fruits, lemons, oranges, &c. The ſalt beſt known of this kind in commerce, is called ſalt of ſorrel. It has been long ſuppoſed to have been obtained from the aleluia, or oxys, but it is now affirmed to be really extracted from a kind of ſorrel, in many parts of Switzerland. This ſalt has the form of white irregular cryſtals,

cryſtals, of a ſharp taſte, and reddens blue vegetable colours,

It diſſolves readily in water, and may be cryſtallized without loſing its acid. By heat, in a crucible, it exhales a ſtrong acid ſmell, becomes carbonaceous, and takes fire. Its flame is blue, like that of ſpirit of wine, and leaves, after its combuſtion, a white ſalt, which with ſpirit of ſalt forms marine ſalt. An ounce of this ſalt afforded Mr. Baumé, by diſtillation, three drachms and a half of an acid colourleſs liquor, with a ſlight ſmell of marine acid. No oil paſſed it over; the reſidue was coaly. This ſalt precipitates the nitrous ſolution of mercury, as does likewiſe the acid it affords by diſtillation. The latter, mixed with the nitrous acid, did not diſſolve. Bergman places the acid of ſorrel as a peculiar acid, in the thirteenth column of his table of affinities. He differs from Baumé in certain particulars, though he agrees with him in moſt, as we ſhall obſerve; but he has not ſaid whether his experiments were made with the ſalt of ſorrel in commerce, or the true eſſential ſalt of ſorrel. The following is an extract of his doctrine reſpecting this ſubſtance. Salt of ſorrel conſiſts of the vegetable alkali, ſuperſaturated with a peculiar acid. Scheele has contrived a very good method of obtaining this acid ſalt. He mixed the oxaline acid, ſaturated with volatile alkali, with a ſolution of

of ponderous earth, in the nitrous acid: the principles of theſe two compounds were mutually changed by double affinity; the ponderous earth uniting with the oxaline acid, forming the barytic oxate of Mr. De Morveau, and falling to the bottom, on account of its difficult ſolubility. This precipitated ſalt is decompoſed by the vitriolic acid, which has a ſtronger affinity with ponderous earth than any ſubſtance hitherto known. The oxaline acid remains diſengaged in the ſupernatant liquor, which is decanted from the ponderous ſpar, formed during the decompoſition. This ſalt ſeems to reſemble the acid of ſugar, rather than that of tartar, though it differs from both. For, when combined with a ſmall quantity of vegetable alkali, it forms ſalt of ſorrel, ſimilar to that of tartar; but which decrepitates in the fire, melts, becomes almoſt black, and capable of being totally decompoſed by chalk: theſe properties are not found in tartar. A ſmall proportion of vegetable alkali combined with acid of ſugar, reſembles neither tartar nor ſalt of ſorrel. The oxaline acid prefers lime to alkalis; but it is yet uncertain whether ponderous earth and magneſia have likewiſe a ſtronger affinity to this acid. It decompoſes ſelenite; becauſe it has a ſtronger affinity than the vitriolic acid with lime. If the oxaline acid be ſtrongly heated, it is deſtroyed; but it neither ſwells, nor be-

comes

comes ſo black, as the acid of tartar. By diſtillation, it affords a phlegm, much more acid than that which is obtained from the latter by the ſame proceſs. From theſe circumſtances we may perceive, that the difference between Bergman and Baumé, conſiſts in the former admitting the vegetable alkali as the baſe of this ſalt; whereas the latter chemiſt found it to contain ſalt of ſoda.

All the acid ſalts of plants have not yet been examined, though a great number is known. The acid of lemons may be ſeparated from its mucilage by ſtanding, and concentrated by the action of froſt, as Mr. Georgius has ſhewn; or by evaporation, carefully conducted. It has been thought analogous to the acid of tartar, though its ſtronger taſte ſeems to indicate a reſemblance with the oxaline acid. Stahl affirms this acid, ſaturated with crab's eyes, and digeſted with a ſmall quantity of ſpirit of wine, gradually aſſumes the nature of vinegar. Bergman obſerves, that the acids of ſpar, phoſphorus, arſenic, borax, ſugar, tartar, ſorrel, and lemons, reſemble each other, in being ſcarcely at all ſoluble when combined with earths; and that they only become ſo, by means of an exceſs of acid; a property which is not found in other ſalts. Yet ſelenite and ponderous ſpar, two earthy ſalts, formed by the vitriolic acid, are ſcarcely ſoluble in water.

Fruits,

Fruits, which are at firſt ſour, and become ſweet as they ripen, afford a ſalt, whoſe acid is leſs developed than that contained in the foregoing ſubſtances. This ſalt ſeems to occupy the middle place between the very acid eſſential ſalts, and the ſaccharine matter, and reſembles the tartar of wine. It is obtained from apples, pears, quinces, tamarinds, &c. Rouelle the younger, has examined it carefully in many of theſe vegetables. We ſhall ſpeak more largely concerning it when we attend to the ſpiritous fermentation.

Modern chemiſts ſeem inclined to think, that all the acids of ſour fruits differ from each other, and compoſe particular ſpecies. Bergman and Scheele are of this opinion. The latter ſucceeded in cryſtallizing the acid of lemons, by ſaturating the juice with chalk, and decompoſing the ſalt by the addition of vitriolic acid; the acid of lemons is diſengaged in the ſupernatant liquor, and may be obtained in cryſtals by evaporation and cooling. We ſhall hereafter ſee, that this cryſtallized acid differs from lemon juice, and does not afford the ſame reſult with the nitrous acid.

CHAP.

CHAP. V.

Concerning the Saccharine Matter.

THE ſaccharine matter, which many chemiſts conſider as a kind of eſſential ſalt, is found in a great number of vegetables, and may be properly ranged among their immediate principles. The maple, the birch, the red beet, the parſnip, the grape, wheat, &c. contain it. Margraff extracted it from moſt vegetables. The petals of many flowers, and the nectariums placed in thoſe organs, elaborate a principle of this kind.

The ſugar cane, arundo ſaccharifera, contains it in larger quantities, and affords it more readily, than any other plant. The ripe canes are cruſhed between two iron cylinders, placed perpendicularly. The expreſſed juice falls on a plate beneath, and is called melaſſes. It flows into a caldron, where it is boiled with wood-aſhes and lime, and the ſcum taken off. This boiling with aſhes and lime is repeated in three other boilers, and converts it into ſyrup. It is then ſtrongly boiled with lime and alum; and when it is ſufficiently concentrated, it is poured into a veſſel called the cooler. When

When it is cooled ſo that the finger may be plunged into it without injury, it is poured into barrels placed over certain ciſterns, and pierced at the bottom with many holes, ſtopped with canes. The ſyrup becomes ſolid in the caſks, and part flows out through the holes into the ciſtern beneath. The ſugar in this concrete ſtate is yellow and greaſy; it is called muſcovado. It is refined in the ſugar iſlands by boiling, and pouring into inverted earthen cones, called pans. That part of the ſugar which is incapable of becoming concrete, runs through the aperture of the pan into a pot placed beneath. The baſe of the ſugar loaves is taken away, and white ſugar in powder is put in its place, and preſſed down; the whole is then covered with moiſtened clay. The water of the clay filtrates through the ſugar, and carries with it a portion of the mother water, which runs out through the aperture at bottom, and is received in other pots. A ſecond covering of clay is put on when the firſt is dry, and the water is ſuffered to filter through a ſecond time; after which, the loaves are carried to a ſtove to dry. At the end of eight or ten days theſe loaves are broken, and the powdered ſugar is conveyed to Europe, where it is refined into ſugar of different qualities.

The proceſs of refining conſiſts in boiling the ſugar in lime-water, together with bullocks

locks blood, taking off the ſkim three or four times, and filtering the liquor, which is then poured into pans to make loaves. The loaves are covered with a ſtratum of moiſtened clay, and the water is thus filtered through the ſugar, by the repeated addition of a new ſtratum of clay as the former becomes dry, until the ſugar has acquired the requiſite degree of whiteneſs. The loaves of refined ſugar are then conveyed into a ſtove, and at the end of eight days are wrapped in paper, and tied up for ſale. The remaining ſyrup, which cannot be cryſtallized, is ſold under the name of melaſſes.

All chemiſts formerly ſuppoſed, that theſe different operations ſeparate a fat matter from ſugar, and by that means render it ſuſceptible of cryſtallization. Bergman thinks, that lime ſerves to deprive it of that exceſs of acid, which prevents its taking the ſolid form. As it is quickly evaporated during the whole proceſs, it takes the form of a granulated and irregular maſs, in the ſame manner as we have before obſerved with reſpect to the vitriol of zink.

Sugar conſiſts of a peculiar acid united to a ſmall quantity of alkali, and much fat matter. It cryſtallizes in hexahedral truncated priſms, and in this ſtate is called ſugar-candy. By diſtillation, it affords an acid phlegm, and a few drops of empyreumatic oil. The reſidue is a ſpungy light coal, which con-

tains a ſmall quantity of vegetable alkali. This ſalt is inflammable. On hot coals it melts, and ſwells up very much, emits a penetrating vapour, and becomes converted into a brown yellow matter called caramel. It is very ſoluble in water, to which it gives much conſiſtence, and conſtitutes a kind of mucilage, called ſyrup. Syrup, diluted with water, is capable of fermentation, and affords ardent ſpirit.

Bergman has obtained, from all ſaccharine matters, eſpecially ſugar, an acid of a peculiar nature. For this purpoſe, one part of ſugar in powder is mixed in a retort with ſix parts of aqua fortis, and a gentle heat is applied. The evaporation is continued for ſome time after the red vapours have ceaſed. The ſolution being ſuffered to cool, affords white cryſtals in the form of four-ſided needles or priſms, terminated with dihedral ſummits. The decanted liquor treated a ſecond time with three or four parts of the ſame nitrous acid, affords, by a new cryſtallization, priſms of the ſame form. The operation is again repeated on the ſecond mother water. An ounce of white ſugar, by this proceſs, affords about three drachms of priſmatic ſalt; which is diſſolved in hot water, and cryſtallized by cooling, in order to obtain it in a ſtate of purity.

The acid of ſugar has a very penetrating ſour taſte. Diluted with water, it forms an

an agreeable acid liquor. It reddens all blue vegetable colours. Expofed to a mild heat, it becomes opake, and falls into a powder, refembling efflorefcence, and lofes three-tenths of its weight, by the evaporation of the water which enters into its cryftals. This water may be collected by the ufual apparatus for diftillation. A ftronger heat fufes the acid, and gives it a brown colour; an acid phlegm paffing at the fame time into the receiver, fimilar in all its properties to the falt itfelf. Part fublimes in the form of a white cruft; and the retort contains fcarcely any refidue. The refidue is grey or brown, and does not amount, according to Bergman, to more than the fiftieth part of the original matter. A very confiderable quantity of a gafeous fubftance is likewife afforded in this operation: half an ounce of the acid of fugar afforded Bergman 100 cubic inches of gas, half of which was cretaceous acid, and the other half inflammable gas, which burned with a blue flame. The Abbé Fontana, who repeated this experiment, obtained from an ounce of the cryftallized falt, 432 inches of gas, of which one third was cretaceous acid, and the reft inflammable gas, mixed with common air. On repeating the fame experiment, I had a refult nearly agreeing with that of the latter chemift. The moft fingular circumftance is, that the fublimed portion diftilled for two more fucceffive times

affords no coaly matter, but only a reſidue of a whitiſh grey colour. This ſalt heated in an open fire, emits a very penetrating vapour, and leaves a reſidue which is perfectly white.

The acid of ſugar expoſed to the air, effloreſces in proceſs of time.

Cold water diſſolves half its weight of this ſalt; but boiling water diſſolves double the quantity. The ſalt cryſtallizes as it cools.

The acid of ſugar diſſolves the baſe of alum. The evaporated ſolution affords a yellowiſh, tranſparent, ſweet, aſtringent, matter, which becomes moiſt in the air, and reddens turnſole. This ſalt boils up in the fire, loſes its acid, and leaves the clay of a brown colour. It is decompoſable by mineral acids.

The acid of ſugar, combined with ponderous earth, forms a ſalt ſcarcely ſoluble, which affords angular cryſtals, when the acid is in exceſs. Hot water, by carrying off this exceſs, renders them opake, pulverulent, and inſoluble.

When combined with magneſia, it affords a white ſalt in powder, decompoſable by the ſparry acid, and by ponderous earth.

Saturated with lime, the acid of ſugar affords a pulverulent ſalt inſoluble in water, and not decompoſable but by fire; becauſe the affinity of this acid with lime is ſuch, that it takes it from every other. Bergman, conſequently,

consequently, proposes the acid of sugar as a test to discover the presence and quantity of lime contained in mineral waters, whether disengaged, or in combination with any acid. This salt turns syrup of violets to a green.

The acid of sugar unites with the vegetable alkali, and may be crystallized, provided either of the principles be in excess. This salt, which is very soluble in water, is decomposable by the action of fire, and by the mineral acids.

Combined with two parts of soda, the acid of sugar forms a salt of difficult solubility, which dissolves more readily in hot than cold water, and turns syrup of violets to a green.

With the volatile alkali it affords an ammoniacal salt, which by slow evaporation, crystallizes in quadrilateral prisms decomposable by fire, and convertible into cretaceous ammoniacal salt, formed by the destruction of the saccharine acid.

The acid of sugar is soluble in the mineral acids. It gives a brown colour to oil of vitriol, and is decomposed by smoking spirit of nitre.

In general, it combines more readily with metallic calces than with metals.

1. With white arsenic it forms very fusible, volatile, prismatic crystals, decomposable by heat.

2. With cobalt, a pulverulent ſalt of a light roſe colour, and difficultly ſoluble in water.

3. With calx of biſmuth, a white ſalt in powder, of difficult ſolubility.

4. With calx of antimony, a ſalt in cryſtalline grains.

5. With nickel, a white or greeniſh yellow ſalt, of difficult ſolubility.

6. With mangaueſe, a ſalt in a white powder, which becomes black by heat.

7. With zink, which it diſſolves with efferveſcence, it forms a white pulverulent ſalt.

8. With calx of mercury, a white pulverulent ſalt, which becomes black by the contact of light. This acid decompoſes the vitriol and nitre of mercury.

9. It at firſt blackens tin, which afterwards becomes covered with a white powder. The ſalt it forms with this metal is of an acrid taſte, and by a well-conducted evaporation, cryſtallizes in a priſmatic form. If quickly evaporated, it affords a tranſparent maſs reſembling horn.

10. It tarniſhes lead, but diſſolves the calces much more readily than the metal itſelf. The ſaturated liquor depoſits ſmall cryſtals, which may likewiſe be obtained by pouring the acid of ſugar into a ſolution of the nitre, or the muriate of lead, as well as into the acetous ſolution of that metal.

11. It

11. It attacks iron filings, and produces inflammable gas. This ſolution is ſtyptic, and affords priſmatic cryſtals, of a greeniſh yellow, decompoſable by heat. The ſaffron of Mars, united to this acid, preſents a yellow powder, ſimilar to that which is obtained by pouring the fluid acid of ſugar into a ſolution of martial vitriol.

12. It acts on copper, and completely diſſolves the calces of that metal, forming a ſalt of a light blue colour, and of difficult ſolubility. This ſalt may likewiſe be obtained by precipitating the ſolutions of copper in the vitriolic, nitrous, muriatic, and acetous acids, by the addition of the acid of ſugar.

13. The calx of ſilver, precipitated by vegetable alkali, is ſparingly diſſolved in this acid. The beſt manner of procuring this ſalt, which Bergman calls ſaccharated ſilver, is to precipitate the nitrous ſolution of this metal by the acid of ſugar: a white precipitate is formed, ſcarcely ſoluble in water, which becomes brown by the contact of light.

14. This acid has ſcarcely any action on the calx of gold.

15. Laſtly, it diſſolves the precipitate of platina, made by ſoda. This ſolution is yellowiſh, and affords cryſtals of the ſame colour. Such are the phenomena deſcribed

 by

by Bergman, reſpecting the combinations of the acid of ſugar with metallic ſubſtances.

It may be ſuppoſed, from the proceſs of this celebrated chemiſt for obtaining the acid of ſugar, that this ſalt is produced from the nitrous acid made uſe of. Bergman does not think that this opinion is admiſſible, becauſe the acid of ſugar has none of the properties of that of nitre, but on the contrary, differs from it in all its combinations. The nitrous acid does not, in fact, appear to enter into the acid of ſugar; but the great quantity of nitrous gas emitted in this proceſs, ſhews, that the ſpirit of nitre is decompoſed. Now, ſince the nitrous acid, according to the experiments of M. Lavoiſier, does not afford nitrous gas, but in proportion as it loſes the baſe of pure air, it appears that a part of its oxyginous principle combines with the combuſtible matter of the ſugar, to form the acid obtained. We have ſeen already, that the production of the arſenical acid, and of the dephlogiſticated muriatic acid, may be explained in this manner.

Though, at the time of the firſt diſcovery of this acid, it was thought that the ſaccharine principle was neceſſary to its formation, it is at preſent known, that a great number of vegetables, which are not ſaccharine, afford it in greater or leſs abundance; ſuch are gums, ſtarch, vegetable gluten, ſalt of ſorrel, le-

mon

mon juice, ſpirit of wine, and many animal matters, as Mr. Berthollet has diſcovered. Among theſe ſubſtances, thoſe which produce the greateſt quantity of this peculiar acid, by the action of ſpirit of nitre, are ſuch as do not afford ſugar. Pure ſugar did not afford Bergman more than one-third of its weight of acid; and Mr. Berthollet obtained more than half from wool. It ſeems, therefore, as M. De Morveau thinks, that this acid is formed by the union of a peculiar attenuated oil, which exiſts in all organic ſubſtances, and is the ſame throughout; and that conſequently the name of ſaccharine acid is improper. Mr. Scheele has obſerved, that the acid of lemons, cryſtallized by the proceſs deſcribed in the foregoing chapter, does not afford ſaccharine acid, by treatment with nitrous acid, though lemon juice itſelf affords it. The vitriolic acid, employed for the purification of this acid ſugar, ſeems, therefore, to decompoſe the oil which forms the baſe of the ſaccharine acid.

Sugar is very extenſively uſeful. It is a food which, taken in too large a quantity, is capable of heating the animal ſyſtem. It is very much uſed in pharmacy, where it is the baſe of ſyrups, lozenges, and other preparations. It is very uſeful, as a medium to favour the ſolution or ſuſpenſion of reſins, oils, &c. in water. It preſerves the juices of

of fruits, after they are reduced into a jelly. It may even be confidered as a medicine, fince it is incifive, aperient, flightly tonic, and ftimulant; and there are, accordingly, inftances of diforders, arifing from obftructions, which have been cured by the habitual ufe of fugar.

Certain juices, which flow out of plants, have a faccharine tafte. Manna and nectar are of this kind. Manna is produced by the leaves of the pine, the oak, the juniper, the willow, the fig-tree, the maple, &c. The afh, which is very abundant in Calabria, Sicily, &c. affords the manna in commerce. It flows naturally from thefe trees, but is much more abundantly obtained by making incifions in their bark. That which is collected on chips of wood, or fmall fticks, introduced into the artificial apertures, forms a kind of ftalactites, perforated within, and called manna in the tear. Manna, in flakes, flows on the bark, and contains fome impurities. The inferior, unctuous fort, contains many foreign fubftances, and confifts of the refufe pieces of the two former kinds: it is always moift, and frequently adulterated. The tafte of manna is fweet, and flightly naufeous. The manna afforded by the larch tree, which abounds in Dauphiny; and that of the alhagi, which grows in Perfia, (Hedyfarum Linn.) in the neighbourhood of Tauris, are not ufed:

ufed: the latter bears the name of tereniabin. Manna is foluble in water, and affords, by diftillation, the fame products as fugar. Treated with lime, and white of eggs, it affords a fubftance refembling fugar; and by the procefs already defcribed with the nitrous acid, it affords an acid of the fame nature as is obtained from fugar.

It is ufed as a purgative, in the dofe of from one to two, or three ounces; or in the dofe of a few drachms, diluted, as an alterative.

CHAP. VI.

Concerning Gum and Mucilage.

ANOTHER kind among the proper juices of plants, is that called gum, or mucilage. This fubftance is very abundant in the vegetable kingdom. It is found in a great number of roots; the young fhoots, and new leaves, contain it in large quantities. This principle may be known by its vifcous and adhefive quality, when thefe parts are crufhed between the fingers. At the time of the year when the juices are moft abundant, it naturally exfudes through the bark of trees, and thickens at the furface into gum. Gum is foluble

ſoluble in water, to which it gives a thick and viſcous conſiſtence. This ſolution, known by the name of mucilage, becomes dry, tranſparent, and brittle, by evaporation.

Gum burns without any ſenſible flame; it melts, and boils up on hot coals; by diſtillation, it affords much acid phlegm, a ſmall quantity of thick and brown oil, and cretaceous acid, in the ſtate of elaſtic fluid. Its coal is very bulky, and contains a ſmall quantity of the fixed vegetable alkali.

Three kinds of gum are uſed in medicine, and in the arts.

1. Gum, which flows from the apricot, pear, plumb trees, &c. It is white, yellow, or reddiſh; and when well ſelected, may be applied to the ſame uſes as other gums. A kind of gummy juice, of a beautiful yellow colour, flows from the elm, and is ſometimes found in conſiderable quantities on its bark. I find this gum to be inſipid, ſoluble, viſcous, and to poſſeſs all the characters of juices of this nature.

2. Gum arabic, which flows from the acacia in Egypt and Arabia. Gum ſenegal is of the ſame nature: it is uſed in medicine as a ſoftening and relaxing remedy; it gives conſiſtence to crayons, and is uſed in ſeveral arts.

3. The gum tragacanth, which flows from the adragant of Crete; tragacantha cretica.

It

It is adminiſtered in the ſame caſes as the foregoing. Its ſolution is ſomewhat thicker; and it requires more water to diſſolve it than the other gums. Viſcous flakes are depoſited from its ſolution.

Mucilages, of the ſame nature as gums, are obtained from many plants. The roots of mallows, the greater comfrey, the bark of elm, linſeed, the ſeed of quinces, &c. afford viſcous fluids, by maceration in water, which, by evaporation, leave true gums. The decoction of theſe plants is ſubſtituted, in medicine, inſtead of gums.

All theſe ſubſtances, chemically conſidered, ſeem, at firſt ſight, to be bodies not much compoſed, ſince chemical experiments often exhibit ſubſtances, which, by their gelatinous form, ſeem to reſemble gums and mucilages. Yet, from theſe vegetable products, which ſeem to conſtitute an excrementitious humour, are obtained water, liquid acid, cretaceous acid, an oily principle, and fixed alkali, united to a coaly reſidue. This reſidue contains likewiſe a fixed earth, whoſe nature is not yet known.

When gums and mucilages are treated with the nitrous acid, they afford a cryſtallized acid, of the ſame nature as that which is improperly called acid of ſugar. It appears, therefore, that they contain the oily principle, whoſe combination with the oxyginous

ginous principle conſtitutes this ſpecies of acid.

The analogy between mucilage and ſaccharine matters, is likewiſe obſervable in the fumes of burned gum, which in ſmell reſemble that of calomel, as well as by the nature of the products both afford by diſtillation, and the poroſity and lightneſs of their reſidual coal. Among fruits which become ſaccharine, there are ſome, as for example, apricots, pears, &c. from which, before the time of their maturity, a true gum exſudes. The kind of dry mucilage, which we ſhall hereafter deſcribe, under the name of amylaceous fecula, is converted into ſaccharine matter by germination. Theſe facts, and many others which might be urged, ſhew, that there is a ſtrong reſemblance between ſugar and gum. The inſipid and gummy mucilage may perhaps paſs to the ſtate of ſugar, by a kind of fermentation. If the fact were eſtabliſhed, it would be proper to place this fermentation before that which Boerhaave has diſtinguiſhed by the name of ſpirituous; and it would always precede it, whether in the proceſs of vegetation, or in thoſe operations which are artificially made to produce the ſaccharine taſte in barley, &c.

CHAP.

CHAP. VII.

Of Fat Oils.

OILS are proper juices of a fat and unctuous nature, either ſolid or fluid, indiſſoluble in water, combuſtible with flame, and volatile in different degrees; they are contained in the proper veſſels, or in peculiar veſicules. Theſe ſubſtances are found in two ſtates in vegetables; either combined with other principles, as in extracts, mucilages, &c. or at liberty. Our attention muſt at preſent be directed to the latter.

Chemiſts have ſuppoſed the exiſtence of a ſimple oily principle, as well as of a primitive ſalt. This oily principle, combined with different ſubſtances, and modified by theſe combinations, conſtituted, according to them, the different ſpecies of oils obtained in the analyſis of vegetables. The characters attributed to this ſimple and primitive oil, were great fluidity and volatility, neither colour nor ſmell, combuſtibility with flame and ſmoke: it was ſaid to be incapable of uniting with water, and to conſiſt of an acid combined with an earth and phlogiſton.

It

It is certain that oils, in their decompoſition, always afford a ſmall quantity of acid, and much inflammable gas; the earth forms but a ſmall part, as they leave but an inconſiderable quantity of fixed and coaly reſidue. This notion reſpecting the oily principle, muſt be conſidered as a mere hypotheſis.

Oils are never formed but by organic bodies, and all ſubſtances in the mineral kingdom, which preſent oily characters, have originated from the action of vegetable or animal life. It is even very probable, that they are only formed in vegetables, and that they paſs without alteration into animal ſubſtances.

The oily juices of vegetables are diſtinguiſhed into fat oils and eſſential oils.

Fat oils are very unctuous; their taſte is commonly mild and inſipid, and they have no ſmell; they are not volatilized but by a heat ſuperior to that of boiling water, and do not take fire till heated ſufficiently to volatilize them. The wick which is uſed to burn fat oil in lumps, anſwers this purpoſe; it heats the oil to ſuch a degree, as volatilizes it.

Moſt fat oils are fluid, and require a conſiderable degree of cold to congeal them; others become ſolid by a very ſlight degree of cold; and others again are almoſt always ſolid: theſe laſt are called butters.

Fat oils are not emitted from the ſurface of vegetables, but are contained in the kernels,

nels, the pippins, and emulſive ſeeds. They are extracted by breaking the cellules by which they are encloſed; that is to ſay, by pounding and preſſure.

Fat oils expoſed to air are changed, and become rancid; their acid becomes developed, and they loſe their properties, at the ſame time acquiring others, by which they more nearly reſemble eſſential oils. Water and ſpirit of wine, by waſhing off this diſengaged acid, deprive them of their ſtrong taſte, but never reſtore their original ſtate.

Mr. Berthollet has diſcovered, that fat oils thinly ſpread on the ſurface of water, and expoſed to the air, become thick, and reſemble wax. This appears to ariſe from the abſorption of the baſe of vital air.

By diſtillation they afford an acid phlegm of a penetrating ſmell, a light oil, a denſer oil, and a large quantity of inflammable gas mixed with cretaceous acid. The quantity of reſidual coal is not abundant. By rediſtilling theſe, more phlegm, and an oil which becomes lighter each time, are obtained. This is known by the name of philoſophical oil; the alchemiſts prepared it by diſtilling, for ſeveral ſucceſſive times, an oil with which they had impregnated a brick. It is not exactly known how far this decompoſition may be carried, though it is ſaid that fat oil may this way be reduced into the diſengaged inflammable principle, acid, phlegm, air, and earth.

Water does not produce any change in fat oils in the cold, but it purifies them, by carrying off part of their mucilage, which is likewiſe precipitated during their combuſtion, and is the cauſe of their property of fermenting and becoming rancid. It is well known, that water thrown on burning oils, cauſes them to give a ſtronger flame, inſtead of extinguiſhing them. This depends on the vital air afforded by the decompoſition of the water, which affords the baſe of vital air. When the vapour of the flame of burning fat oil is collected in a chimney, terminated by a worm pipe, a large quantity of water is obtained: whence it follows, that this immediate principle of vegetables contains an aqueous inflammable gas.

Fat oils do not combine with ſiliceous earth: with clay they form a ſoft paſte uſed in chemiſtry, by the name of fat lute.

By particular proceſſes they combine with magneſia, which reduces them to a ſaponaceous ſtate.

Lime unites with oils, but not in a very evident manner when the ſubſtances are immediately applied to each other.

Pure alkalies combine readily with fat oils, and produce a compound called ſoap.

To prepare this compound, oil of olives, or of ſweet almonds, is triturated with a concentrated lixivium of ſoda, rendered cauſtic

tic by lime, and known by the name of ſoap lye. The mixture becomes thick in a few days, and is converted into the ſoap uſed in medicine. The ſoap of commerce is made by boiling the lixivium with rancid oil; it is then white, but is marbled by martial vitriol. Green ſoap is made with the marc of olives and pot aſh.

Soap is ſoluble in pure water: heat decompoſes it, and diſengages phlegm, oil, and volatile alkali produced from the fixed alkali and the oil; the coal contains much fixed alkali. This artificial compoſition of volatile alkali ſeems to prove, that fixed alkalies contain mephitis, which reacts on the inflammable gas of the oil.

Lime-water decompoſes ſoap, according to the obſervation of Mr. Thouvenel; an inſoluble calcareous ſoap is then formed, which is depoſited in grains. Acids poured on ſoap diſengage the oil, but ſomewhat altered.

The volatile alkali does not combine with fat oils without difficulty; yet, by long trituration the mixture becomes opake, and rather more conſiſtent.

Fat oils unite with acids, and form peculiar ſoaps, when the acid made uſe of is weak. Meſſrs. Achard, Cornette, and Macquer, have made experiments reſpecting theſe compounds. Mr. Achard added concentrated vitriolic acid, by ſmall portions, to fat oil.

This mixture being continually triturated, becomes at length converted into a brown mafs, foluble in water and fpirit of wine. The oil obtained from this foap by alkalies, as well as by diftillation, is always more or lefs concrete. Mr. Macquer advifes, in making this foap, to pour the acid on the oil; but he obferves, that an acid foap made in this manner, is fcarcely foluble in water. The foap which is prepared by triturating common alkaline foap with oil of vitriol, is more foluble. The concentrated vitriolic acid renders fat oils black, and caufes them to refemble bitumens. This phenomenon appears to arife from the re-action of the inflammable gas of the oil on the oxyginous principle of the vitriolic acid.

The fuming nitrous acid immediately changes fat oils to a black colour, and inflames fuch as are of a drying nature. Thofe which do not dry cannot be inflamed, but by a mixture of fpirit of nitre and oil of vitriol, as Rouelle the elder has fhewn in his Memoirs on the Inflammation of Oils, printed among thofe of the Academy for the year 1747.

The muriatic and cretaceous acids, act but weakly on fat oils; the former, however, in a concentrated ftate, combines with them to a certain degree, according to Mr. Cornet. The dephlogifticated muriatic acid thickens them much, and appears, by the abforption

abſorption of its oxyginous principle, to convert them into a ſubſtance nearly reſembling wax.

The action of the other acids on fat oils, is not known; theſe oils do not appear to combine with neutral ſalts. Many of the latter, more eſpecially the calcareous ſalts, decompoſe alkaline ſoaps. In this decompoſition, eſpecially that effected by the vitriols of lime and magneſia, which are frequently contained in water, the vitriolic acid unites with the fixed alkali of the ſoap, and forms vitriol of ſoda; the lime or the magneſia combines with the oil, and forms a kind of ſoap ſcarcely at all ſoluble, which floats in whitiſh curd-like maſſes on the ſurface of the water. This is the cauſe of the common appearance produced by hard waters, when attempts are made to uſe them with ſoap.

The action of inflammable gas on fat oils has not yet been examined.

Fat oils diſſolve ſulphur in a boiling heat, and this ſolution is of a deep browniſh red colour, of a very fetid ſmell, and gradually depoſits ſulphur in the cryſtalline form. When this combination is diſtilled, the ſulphur is totally decompoſed, and is no where found. This experiment well deſerves to be carefully repeated. Sulphureous gas is likewiſe obtained in this decompoſition.

Fat oils do not appear capable of uniting with pure metallic ſubſtances, excepting copper and iron, on which they have a conſiderable action. But they combine with metallic calces, and form thick, concrete combinations, of a ſoapy appearance, as may be obſerved in the preparation of unguents and plaſters. Theſe preparations have not yet been chemically examined; it is only known, that certain metallic calces are reduced in the formation of plaſters; as for example, the calces of copper and lead, &c. In docimaſtic operations, fat oils are uſed to reduce metallic calces. Mr. Berthollet deſcribes an ingenious and ſimple proceſs, for immediately combining a fat oil with any metallic calx, in the ſaponaceous form. It conſiſts in pouring a ſolution of ſoap into a metallic ſolution; the acid of the latter ſeizes the fixed alkali of the ſoap, and the metallic calx is precipitated in combination with the oil, to which it communicates its colour. In this manner a beautiful green ſoap is formed with vitriol of copper, and a brown ſoap with vitriol of iron; theſe compounds may perhaps be uſeful in painting. M. Scheele has diſcovered, that by combining oil of ſweet almonds, of olives, of rape, or of linſeed, with the calces of lead, and adding a ſmall quantity of water to the mixture, a ſubſtance is ſeparated, which he calls the ſweet principle. By

evaporating

evaporating the water, this principle is obtained, of the confiftence of fyrup; by a ftrong heat it takes fire; part is volatilized in the diftillation without burning; the refidual coal is very light. The fweet principle does not cryftallize, nor does it appear fufceptible of fermentation; nitrous acid diftilled four times from it, produces acid of fugar. This principle appears to be a kind of mucilage.

Fat oils diffolve bitumens, and in particular amber, but they require the affiftance of heat. Thefe combinations are a kind of fat varnifh, which does not become dry without difficulty.

Fat oils may be diftinguifhed into three genera.

The firft comprehends pure fat oils, which congeal by cold, thicken flowly, form foaps with acids, and do not take fire by the nitrous acid, unlefs oil of vitriol be likewife ufed.

1. Such are oil of olives obtained from the pulp of that fruit, crufhed between two mill-ftones, and preffed in facks made of rufhes. The firft product is called virgin oil; that which is obtained from the marc, moiftened with water, is lefs pure, and depofits a fediment. The oil of unripe olives is the oleum omphacine of the ancients. Oil of olives freezes at 10 degrees below zero, on Reaumur's thermometer, or ten de-

 grees

grees and a half above zero, in the thermometer of Fahrenheit, and does not become rancid in lefs than about twelve years.

2. Oil of fweet almonds extracted without heat, becomes quickly rancid; it does not freeze till its temperature is reduced to 6 degrees below o of Reaumur's fcale, or 17 and a half of Fahrenheit.

3. Oil of rape obtained from the feeds of a kind of cabbage called colfa.

4. Oil of ben, extracted from the ben nut, from Egypt and Arabia; it is very acrid, inodorous, and freezes very eafily.

The fecond genus comprehends drying oils, which foon become thick, do not congeal with cold, are inflamed by the nitrous acid alone, and form a kind of refin with vitriolic acid.

1. Such are linfeed oil, obtained by preffure from linfeed. It is ufed in oily varnifhes, and in painting.

2. Nut oil applied to the fame ufe.

3. Oil of poppy feeds, which is not at all narcotic, as the Abbé Rozier has clearly fhewn.

4. Oil of hemp feed, which is very drying.

In the third genus we comprehend concrete fat oils, or butters, among which we may diftinguifh the following.

1. Butter of cocoa, obtained from the chocolate nut: four fpecies of cocoa are diftinguifhed;

diſtinguiſhed; the large and ſmall caracca, the berbice, and that of the iſlands. The butter is extracted by roaſting and ſubſequent ebullition in water, and is purified by melting with a gentle heat.

2. The cocoa nut affords a butter of the ſame kind.

3. The wax of vegetables is of the ſame kind, excepting that it is more ſolid; it comes from China, where it is made into yellow, green, or white candles, according to the manner in which the wax is extracted. The catkins of birch and poplar, afford a ſmall quantity of this kind of wax. That of Louiſiana is more abundant; M. Berthollet quickly bleaches it with the dephlogiſticated marine acid.

The uſe of fat oils in the arts, and in medicine, is very extenſive. They are medically preſcribed as relaxing, ſoftening, and laxative remedies; ſome are even purgative, as the oil of Ricinus, or Palma Chriſti, which has been likewiſe diſcovered to poſſeſs the property of deſtroying and evacuating the ſolitary worm. They enter into many medical compounds, ſuch as balſams, unguents, plaſters, &c. they are often uſed as food, on account of the mucilage they contain.

CHAP.

CHAP. VIII.

Concerning Eſſential Oils.

ESSENTIAL oils differ from fat oils, by the following characters: Their ſmell is ſtrong and aromatic: Their volatility is ſuch, that they riſe with the heat of boiling water: and their taſte is very acrid. They are likewiſe much more combuſtible than the fat oils. Theſe oils exiſt in moſt ſtrong ſmelling plants. They are either contained in the whole plant, as in the Bohemian angelica, or in the root only, as in ſtarwort, the iris, the white dittany, and the kidney-wort, &c.; or in the ſtem, as in the woods of ſandal, ſaſſafras, pine, &c. or in the bark, as in cinnamon. In ſome, the leaves only contain it, as is obſerved in balm, peppermint, wormwood, &c. in other plants it is found in the calices of the flowers, as in the roſe, and lavender. The petals of camomile and orange flower abound with it. In others again, it is contained in the fruits, as in cubebs, pepper, juniper berries, &c. Laſtly, many vegetables contain this oil in their ſeeds, as nutmeg, aniſe, fennel, and moſt umbelliferous plants. Eſſential oils differ from

from each other, 1. In the quantity, which greatly varies according to the ſtate or age of the plant. 2. In conſiſtence: ſome are very fluid, ſuch as thoſe of lavender, blue, &c.; others congeal by cold, as the oils of aniſeed, or fennel; others again are always concrete, as thoſe of roſes, parſley, kidney-wort, and ſtarwort. 3. With reſpect to colour: ſome are colourleſs, others yellow, as that of lavender; others deep yellow, as that of cinnamon; others blue, as that of camomile; others ſea-green, as that of St. John's-wort; or green, as that of parſley. 4. By their weight: ſome float on water, as moſt of the oils extracted from plants growing in temperate countries; others, as thoſe of ſaſſafras and carraway ſeeds, and moſt oils from hot countries, ſink to the bottom. This property is not, however, conſtant with reſpect to climates, the eſſential oils of nutmeg, pepper, and mace, being lighter than water. 5. With reſpect to ſmell and taſte: this laſt property is often very different in the eſſential oil from that of the plant. For example, pepper affords a mild oil, and the oil of wormwood is not bitter.

Eſſential oils are obtained, 1. By preſſure, from the cedra, from bergamot, from lemons, oranges, &c. 2. By diſtillation. For this purpoſe, the plant is put into a copper alembic, together with water; the

water

water being made to boil, comes over together with the oil into the receiver, and is obtained ſeparate by decantation.

Eſſential oils are adulterated either by the addition of fat oils, which may be known by the ſtain ſuch oils make on paper; or by oil of turpentine, which may be diſtinguiſhed by its ſtrong ſmell, that remains after the eſſential oil is evaporated. The addition of ſpirit of wine in moſt caſes diſcovers the adulterating ſubſtance which remains undiſſolved, while the oil unites with the ſpirit.

Eſſential oils loſe their ſmell by a gentle heat, as they are very volatile; fire alone does not decompoſe them. When heated with contact of air, they quickly take fire, and emit a very thick fume, which becomes condenſed into a fine and light coaly matter: they leave very little fixed coal after their inflammation; becauſe they are ſo volatile, that the coaly matter is formed in the part which riſes.

By expoſure to the air they become thick, and in proceſs of time aſſume the character of reſin. Needle-formed cryſtals are depoſited ſimilar to thoſe afforded by camphire when ſublimed. Geoffroy the younger, obſerved them in the eſſential oils of motherwort, marjoram, and of turpentine. The ſame chemiſt obſerves, that their ſmell is ſimilar to that of camphor.*

They unite difficultly with lime and alkalis,

* See the Memoirs of the Academy for the year 1721.

lis, and are changed by acids. The concentrated vitriolic acid converts them into bitumens; but if it be weak, it forms a kind of ſoap. The nitrous acid cauſes them to burſt into flame; the muriatic acid renders them ſaponaceous; and the dephlogiſticated marine acid thickens them.

They have no action on neutral ſalts.

They combine very readily with ſulphur, and form compounds, called balſams of ſulphur, in which the ſulphur is ſo far changed, that it cannot be again recovered.

Mucilages and ſugar render them ſoluble in water.

They are uſed as cordial, ſtimulant, antiſpaſmodic, &c. remedies. Externally applied, they are powerfully antiſeptic, and ſtop the progreſs of caries in the bones.

CHAP. IX.

Concerning the Camphorate Principle.

CAmphor is a white concrete cryſtalline matter, of a ſtrong ſmell and taſte, which reſembles eſſential oils in ſome of its properties, and differs from them in others.

From a number of obſervations, chemiſts conſider camphor as an immediate principle of vegetables, exiſting in all very odorife-

rous

rous plants, that contain essential oil. It has been obtained from the roots of zedoary, thyme, rosemary, sage, and other labiated plants, either by distillation or decoction, as Cartheuser and Neumann have observed; but this camphor is in small quantities, and always has the smell of the plant from which it is obtained. This singular substance seems to be combined with the essential oils of vegetables, as we may conclude from the observation of Geoffroy, mentioned in the foregoing chapter. M. Josse, apothecary at Paris, shewed me a true camphor obtained from the roots of starwort. Lorry considered camphor as a principle abounding in vegetables, and placed its spiritus rector at the head of a class of very powerful smells, whose effects on the animal economy deserve the attention of chemists and physicians.

The camphor used in medicine, is obtained from a species of laurel which grows in China, Japan, and in the islands of Borneo, Sumatra, Ceylon, &c. The tree which produces it, sometimes contains so large a quantity that it need only be cleft, in order to obtain very pure tears of camphor, of considerable size. It is obtained by distillation. The roots, or other parts of the tree, are put into an alembic with water,. which is covered with a capital, containing ropes of rice straw. On the application of a sufficient heat, the camphor

camphor is ſublimed in ſmall greyiſh grains, which are afterwards united into larger maſſes. This crude camphor is impure; the Dutch purify it by ſublimation, after previouſly adding an ounce of lime to each pound of the camphor.

Camphor is much more volatile than eſſential oils and ſubſtances: with the moſt gentle heat, it cryſtallizes in hexagonal laminæ, attached to a middle ſtem. By a ſudden heat it melts before it riſes. It does not ſeem decompoſable by this means; yet if it be repeatedly diſtilled, it affords a reddiſh and manifeſtly acid phlegm, which ſeems to ſhew that the whole might be decompoſed by repeating the operation a ſufficient number of times. The temperature of the air in ſummer volatilizes it, ſo that it is intirely diſſipated. In a cloſe veſſel it ſublimes in hexagonal pyramids, or polygonal cryſtals, which were obſerved and deſcribed in the year 1756, by Romieu. Its ſmell is ſtrong and inſupportable to ſome perſons; it takes fire readily, burns rapidly with much ſmoke, and leaves no carbonaceous reſidue.

It does not diſſolve in water, to which, nevertheleſs, it communicates its ſmell: it burns on the ſurface of water. Romieu has obſerved, that ſmall pieces of camphor, of the third or fourth part of a line in diameter, on the ſurface of a glaſs of pure water, have

have a rotatory motion, and are diſſolved in the ſpace of half an hour. He ſuſpects that this motion is produced by electricity, and obſerves that it ceaſes when the water is touched with a body that conducts electricity, ſuch as an iron wire; and that on the contrary, it continues, though the water be touched with an inſulating ſubſtance, ſuch as glaſs, reſin, ſulphur, &c.

Earths, the ſalino-terreſtrial ſubſtances, and alkalis, have no action on camphor. It muſt, however, be obſerved, that experiments have not yet been made with the cauſtic alkalis.

Concentrated acids diſſolve camphor. Oil of vitriol, aſſiſted by heat, diſſolves it, and becomes red. The nitrous acid diſſolves it without any inteſtine motion, and forms a yellow liquid, which, becauſe it floats on the acid, has been called oil of camphor. The muriatic acid, in the ſtate of gas, diſſolves camphor; as do likewiſe the ſulphureous and ſparry gaſes. If water be added to theſe ſolutions, they become turbid, and the camphor is ſeparated in flocks, which float on the ſurface of the liquid, and does not appear to have ſuſtained any change in its properties. Alkalis, and alſo the ſalino-terreſtrial ſubſtances, and metallic matters, likewiſe ſeparate camphor from acids.

Neutral ſalts have no action on camphor. The action of ſulphur and bitumens on this ſubſtance

ſubſtance is not known, though it is probable they would unite with it.

Fat oils, and eſſential oils, diſſolve camphor by the aſſiſtance of heat. Theſe ſolutions, by cooling, gradually depoſit cryſtals in a vegetation ſimilar to that which is formed in ſolutions of ſal ammoniac; namely, a middle ſtem, in which very fine horizontal threads are inſerted. This kind of feathers, examined by the magnifier, is very beautiful and regular. Romieu was the firſt who obſerved this beautiful cryſtallization (Memoirs of the Academy for 1756, page 448). We ſhall hereafter ſee that the ſolution of camphor in ſpirit of wine, which is much better known and more uſed than the foregoing, preſented this obſerver with a cryſtallization ſomewhat different, which he obtained by a peculiar proceſs. Camphor is one of the moſt powerful remedies the art of medicine poſſeſſes. It diſſipates inflammatory tumours in a ſhort time, by external application. It is uſed as an antiſpaſmodic, and as an antiſeptic remedy in contagious diſorders, putrid fevers, and in general, in all diſorders which are attended with nervous affections, or putridity. It is not adminiſtered in France in larger doſes than a few grains; in Germany, and in England, it is given in the quantity of ſeveral drachms per day. It is of importance to be known, that

camphor often mitigates heat and pain in the urinary paſſages, as it were by inchantment. It is given, triturated with yolk of eggs, ſugar, gums, or in the ſtate of oil of camphor; and is ſometimes uſed in the compoſition of diet drinks. Surgeons uſe camphorated ſpirit of wine, whoſe compoſition we ſhall hereafter deſcribe, in external gangrenes, and often with good ſucceſs.

CHAP. X.

Concerning the Spiritus Rector.

BOerhaave gave the name of ſpiritus rector to the principle in which the ſmell of plants reſides. The properties of this ſingular ſubſtance, ſo intereſting on account of its effects on the animal economy, are yet but little known. The ſpiritus rector appears to be exceedingly volatile, fugacious, and attenuating. It is continually diſengaged from plants, and forms an odoriferous atmoſphere around them, to a greater or leſs diſtance. All plants differ from each other in the quantity, efficacy, and nature of this principle. Some contain it in great abundance, and are only in part deprived of it by drying, ſo that in theſe it appears to poſſeſs

poſſeſs a certain degree of fixity. Such, in general, are the odoriferous woods, and all the dry and ligneous parts of ſtrong-ſmelling vegetables. In others, this principle is ſo volatile and tranſient, that though they have much ſmell, the ſpiritus rector can ſcarcely be retained, even with the greateſt difficulty. Laſtly, there are plants, which have a ſmell ſcarcely ſenſible; theſe are called inodorous, and their ſpiritus rector has been diſtinguiſhed by the appellation herbaceous.

The ſlighteſt heat is ſufficient to diſengage the ſpiritus rector of plants. To obtain this principle, the plant muſt be diſtilled in a water-bath, and the vapours received in a head, which being kept cool, may condenſe them, and cauſe them to paſs into the receiver in a liquid form. This product is a limpid water, charged with the principle of ſmell, and is called the eſſential, or diſtilled water of the plant. The odorous principle is more volatile than the fluid which holds it in ſolution. Heat drives off the ſpiritus rector, and the liquid becomes, of courſe, deprived of its peculiar ſmell; expoſure to air produces the ſame effect, very light mucilaginous flocks being depoſited, and the ſmell of the fluid being changed to that of mouldineſs.

The principle of ſmell unites with the oily juices, and even ſeems to be one of the component parts of eſſential oils; for, 1. They

always abound with it. 2. Plants which have a permanent ſmell, conſtantly afford more eſſential oil than thoſe whoſe principle of ſmell is very volatile, and which often afford no eſſential oil, as is the caſe with liliaceous plants. To retain the ſpiritus rector of theſe laſt, as the lilly, the jeſſamine, the tuberoſe, it is neceſſary to combine them with fat oil. Theſe flowers are placed in a cucurbit of tin, together with cotton ſoaked in the oil of ben: the flowers and the cotton are diſpoſed ſtratum ſuper ſtratum; and the cucurbit being cloſed, a gentle heat is applied. The ſpiritus rector is diſengaged, and combining with the oil, becomes durably fixed. 3. Plants which have no ſmell, do not afford the ſmalleſt quantity of eſſential oil. 4. Vegetables, whoſe ſpiritus rector has been extracted by diſtillation in the water-bath, no longer afford eſſential oil, or at leaſt they do not, unleſs the diſtillation has been ſo managed, that they ſtill retain part of their ſmell; in this caſe, they may afford a very ſmall quantity. 5. An eſſential oil, which has loſt its ſmell, reſumes it very readily, with all its properties, when re-diſtilled from a freſh plant, of the ſame kind as that from which it was originally extracted.

The action of ſaline ſubſtances on the ſpiritus rector has not yet been examined.

The nature of this principle is not identical;

tical, but it ſeems to differ, according to the genera of the plants from which it is obtained. Macquer is of the ſame opinion with Boerhaave, that it is in general compoſed of an inflammable and a ſaline ſubſtance; but he obſerves, that it ſometimes participates more of the ſaline nature, and in other plants is more oily. The ſpiritus rector of cruciferous plants appeared to him to be ſaline; and he gives it the character of being penetrating, without affecting the nerves. That which, on the contrary, is inſipid or ſtrong, without a keen and penetrating ſmell, and affects the nerves in ſuch a manner, as either to produce or mitigate thoſe ſymptoms which depend on their irritation, as is the caſe with aromatic and narcotic plants, participate more of the nature of oils, according to that celebrated chemiſt. Several facts may be brought in ſupport of this aſſertion. The fraxinella emits an odour that forms an inflammable atmoſphere around the plant, which immediately takes fire on the approach of an ignited ſubſtance: the vapour then burns from the bottom to the top of the ſtem which ſupports the flowers. The ſpiritus rector of fraxinella appears, therefore, to be of an oily nature. Venel, a chemiſt at Montpellier, and diſciple of Rouelle, obtained an acid ſpiritus rector from ſavory (marum) by a gentle heat; and Roux, profeſſor of chemiſtry in the ſchools

of medicine, who examined this product, discovered, that it does not redden blue vegetable colours, but that it saturates alkalis. Chemists are not agreed concerning the nature of the spiritus rector of cruciferous plants. Some think that it is acid, and others imagine it to be alkaline. From the experiments of Messrs. Deyeux and Baumé, it appears, that sulphur is found combined with the odorous principle of antiscorbutic plants; and that this combustible substance, in the state of an elastic fluid, constitutes the spiritus rector of cruciferous plants.

Two important considerations remain to be offered concerning the spiritus rector. The first is, that this principle, according to the very probable conjecture of Macquer, is probably a gas of a peculiar nature. Its invisibility and volatility, the manner in which it is expanded and dispersed in the atmosphere, together with certain experiments made by Dr. Ingen-housz on the noxious gas afforded by flowers, render this opinion very probable. It only remains, therefore, to make the proper experimental inquiries on this subject, which it must be confessed require the greatest care and accuracy, but at the same time promise to reward the inquirer with discoveries of the most important kind. Boyle has already opened an immense field, and his labours have been continued with the greatest success.

cefs by Lorry. This philofopher has attended to the alterations which arife from the mixture of odours, and the changes they undergo by fermentation, by the action of fire, of air, or of different menftrua. We cannot, without departing too far from our original plan, enter into any detail of his experiments, and fhall therefore only exhibit his primitive divifion of odours. Lorry divides thefe bodies into five claffes, to which all other odours may be referred; namely, camphorated, etherial, poifonous or narcotic, acid, and alkali. This phyfician, explaining the bafis of his divifion, eftablifhed on the effects of odours on the fenfe of fmelling, and the nerves in general, affirms, that he does not propofe to inquire into their chemical nature; but it is moft probable, as he himfelf thinks, that the chemical properties of each clafs refemble each other, as well as thofe properties they exhibit in relation to the animal economy.

The fecond confideration, with which we fhall terminate our hiftory of the principle of fmell, is, that though the plants called inodorous are confidered as not poffeffing it, it is neverthelefs well afcertained, that by the loweft heat of a water-bath, thefe alfo afford a fluid, whofe fmell, though feeble, is fufficient to difcover the plant from which it was diftilled. I can affert, from many experiments, that plants, reckoned moft

 inodorous,

inodorous, afford, by the water-bath, a diſtilled water, which emits their proper odour, in ſuch a manner as to diſtinguiſh them perfectly from each other. Theſe waters are quickly decompoſed, loſing their faint characteriſtic ſmells, and becoming changed by fermentation, which diſcovers acid or alkaline characters, according to the nature of the ſubſtance.

The art of the perfumer conſiſts in extracting the odorous principles of vegetables, and in preſerving or fixing them in different ſubſtances. Moſt of the proceſſes of this art are intirely chemical.

Diſtilled waters are much uſed in the art of medicine; they poſſeſs different virtues, according to their reſpective nature. Thoſe only are uſed which are diſtilled by a naked fire, with the addition of water, as is done in the extraction of eſſential oils. We may obſerve, that this manipulation is adviſable in making aromatic eſſential waters, but is defective with reſpect to ſuch plants as are commonly called inodorous. We are of opinion, that it is indiſpenſably neceſſary to diſtil them with the water-bath; and as this precaution is not uſually taken, they have commonly an empyreumatic ſmell, inſtead of that of the plant. If the virtue of theſe waters reſide only in their ſpiritus rector, feeble as it may be, it is certain, that the uſual method of preparing them deprives them

them of all the properties they ought to have.

We muſt likewiſe add, that the diſtilled waters of plants, prepared in pharmacy, are not the pure ſpiritus rector, in the ſenſe Boerhaave uſes the word, but that the ſpiritus rector is diluted with a large quantity of water, which comes over in the diſtillation.

CHAP. XI.

Of Inflammable Reſinous Juices in general, and of Natural Balſams in particular.

THE name of reſin is given to a dry, inflammable ſubſtance, not miſcible with water, ſoluble in oils and ſpirits of wine, and which flows in a liquid ſtate from the trees that produce them. Theſe ſubſtances are oils, become concrete by being dried in the air. The difference between balſams and reſins is not well ſettled. Some give the name of balſam to fluid inflammable ſubſtances, though there are likewiſe dry balſams. Others call the moſt odorous inflammable ſubſtances by this name. Bucquet has thrown conſiderable light on this ſubject, by confining the name of balſams to ſuch combuſtible matters

matters as communicate a ſweet taſte to water, and more eſpecially contain odorant and concrete acids, which may be obtained by ſublimation or decoction in water.

The principal ſpecies of balſams may be reduced to the three following:

1. Benzoin; this is diſtinguiſhed into two ſpecies, the benzoe amygdaloides, formed of white tears, reſembling almonds, united by a brown matter: common benzoin is brown, and without tears; it emits a very agreeable ſmell, when fuſed or touched with a hot needle. The tree which affords it is not known; but we receive this balſam from the kingdom of Siam, and the iſland of Sumatra. It affords very little eſſential oil, on account of its ſolidity. Boiling water extracts an acid ſalt, in the form of needles, of a ſtrong ſmell, which cryſtallizes by cooling. It is likewiſe obtained by ſublimation, and is then called flowers of benzoin. This operation is made in two glazed earthen pots, placed one above the other, and cloſed at the place of junction with paper. The ſublimation muſt be performed with a gentle heat, otherwiſe the ſalt will be brown. The paper cone, formerly uſed as a ſubliming chimney, inſtead of the upper pot, cauſes the loſs of a great part of the flowers. The ſmell of this ſalt is ſtrong, and it produces a cough when inhaled. Its taſte is acid; it reddens ſyrup of violets, and efferveſces with the

the cretaceous alkalis. Benzoin, diſtilled in a retort, affords a very acid phlegm, a concrete and brown ſalt of the ſame nature, with a brown and thick oil. The reſidual coal contains fixed alkali.

Bergman and Scheele began the examination of the properties and elective attractions of the acid of benzoin; but their experiments are not ſufficiently numerous to afford any very extended knowledge of this acid and its properties.

Benzoin diſſolves in ſpirit of wine; and its tincture, precipitated by water, affords the lac virginale. The ſalt of Benjamin is uſed as a good inciſive remedy in pituitous diſorders of the lungs and veins. Its oil is diſcuſſive, and is externally applied in paralytic diſorders, &c.

2. Balſam of Tolu, Peru, or Carthagena. It is imported either in cocoa nut ſhells, or in yellowiſh tears, or in a fluid ſtate. It flows from the Toluifera, placed by Linnæus in the decandria monogynia. It may be extracted from the ſhells, by ſteeping them in boiling water, which renders it fluid. It comes from South America, in the tract between Carthagena and Honduras. It affords the ſame products as benzoin, and more particularly the concrete acid. It is made into a ſyrup, and is uſed in diſorders of the lungs.

The acid of balſam of Tolu has not been ſuffi-

ſufficiently examined to determine whether it eſſentially differs from that of benzoin.

3. Storax calamita is in tears, either red and clean, or brown and unctuous. Its ſmell is very ſtrong. It flows from the oriental liquid amber, a plant very little known. Newman analyzed the ſtorax calamita, and obtained a very ſmall quantity of eſſential oil, a concrete acid ſalt, and a thick oil. This balſam is applied to the ſame uſes as benzoin, and is more particularly conſumed by perfumers. It was formerly imported incloſed in reeds, or canes; we now receive it in the form of loaves, or irregular maſſes, of a reddiſh brown colour, mixed with ſome tears of a lighter colour, and of a very agreeable ſmell.

CHAP. XII.

Concerning Reſins.

RESINS differ from balſams in their ſmell, which is leſs agreeable, and eſpecially in their containing no concrete acid ſalt; the principal ſpecies are the following:

1. Balſam

1. Balſam of Mecca, of Judea, of Egypt, of Grand Cairo. It is liquid, white, bitter, and of a very ſtrong ſmell, reſembling that of lemons. It flows from a tree called amyris opobalſamum, placed by Linnæus in the octandria monogynia, and diſcovered in Arabia Felix by Mr. Forſkahl. This liquid reſin affords much eſſential oil, by diſtillation; it is incorporated with ſugar, yolk of eggs, &c. and uſed as a vulnerary.

2. The balſam of copaiba, of a brown or yellow colour, which flows from the tree called copaiba, or copaifera, of Linnæus, and placed by that botaniſt in the decandria monogynia. The common ſort, as well as that of the balſam of Tolu, is a mixture of the true balſam of copaiba and turpentine, according to Cartheuſer. It is uſed in ulcers of the lungs and bladder, like the foregoing.

3. Chio turpentine is afforded by the turpentine tree, which bears piſtachio nuts. It is of a white, or blueiſh yellow colour. By the water-bath, it affords a very fluid eſſential oil; but the oil obtained by a naked fire is leſs fluid. The turpentine, after this proceſs, is yellower; if the diſtillation be made with water, it is white and ſilky, and is called boiled turpentine. This is rarely met with, and is now no longer uſed.

4. Venice turpentine is commonly uſed in medicine, either in its natural ſtate, or combined with fixed alkali. This combination

nation is called Starkey's ſoap. The diſpenſatory of Paris directs four ounces of eſſential oil of turpentine to be poured on half a pound of nitre, fixed by tartar, before it is become cold. The mixture is to be agitated with a ſpatula of ivory, and the veſſel kept covered with a paper, more oil being from time to time added, till the whole forms a white maſs. As this proceſs requires ſeveral months time to complete it, chemiſts have endeavoured to diſcover more expeditious methods of performing it. Rouelle, by triturating the alkali, drop by drop with the ſoap, and adding a ſmall quantity of water towards the end, prepared a conſiderable maſs of this ſoap in the ſpace of three hours. M. Baumé directs one part of alkali of tartar, heated till it fuſes, to be ground on a levigating ſtone, three or four times its weight of eſſential oil of turpentine being gradually added. When the mixture has acquired the conſiſtence of a ſoft opiate, he expoſes it in a moiſt place, in a glaſs veſſel covered with paper. In fifteen days, the deliqueſcent alkali forms a ſtratum of liquor at the bottom of a veſſel, the ſoap is in the middle, and a portion of the oil, of a red colour, floats above. M. Baumé thinks, that the alkali unites only with that portion of the oil which is in the reſinous ſtate. M. Le Gendre carries this notion farther, and propoſes to ſaturate a cold ſolution of fixed alkali

alkali with oil of turpentine become thick, or turpentine itſelf. This ſoap has a certain degree of ſolidity, which gradually becomes more conſiderable; it affords cryſtals, which have been conſidered as a combination of the acid of the oil with the vegetable fixed alkali; but which, according to the academicians of Dijon, conſiſt of the vegetable alkali, ſaturated with the cretaceous acid. As this ſoap is very difficult to make, and ſubject to change, Macquer thinks, that when an union of the properties of eſſential oils with thoſe of ſoap, is deſired, it is more adviſable to incorporate with the white medicinal ſoap, a few drops of that eſſential oil, whoſe qualities may anſwer the intended purpoſe. Pure volatile alkali, triturated with turpentine, forms a ſaponaceous ſolid compound, ſoluble in water, to which it gives a milky appearance.

5. The reſin of fir is called Straſburg turpentine; it is collected by piercing the veſicules of the bark of fir trees, which grow plentifully in the mountains of Switzerland.

6. Pitch is the juice of a kind of fir, called abies picea; it is extracted by inciſions made in the bark of the tree. It is melted by a gentle fire, and ſtrained through ſacks; after which it is received in barrels. Burgundy pitch is white, but the mixture of coaly matter gives the black colour. When pitch is long kept in fuſion with vinegar,

negar, it dries, becomes brown, and forms colophony. The dregs of pitch are burned in a fire-place, whofe chimney leads into a fmall chamber, terminated by a cone made of cloth: in this laft, the fmoke condenfes, and forms the fine foot, called lamp-black.

7. Galipot, or refin of the pine. Holes are bored in the lower part of this tree, through which the refin flows into troughs. Other incifions are made higher up, when the former afford no more. When emitted in the fluid ftate, it is called galipot; the portion which dries on the tree, in yellowifh maffes, is called barras. Thefe juices are melted, and when thickened by heat, are filtered through ftraw mats, and poured into moulds in fand. They then form maffes, called arcancon, or bray-fec. If water be added, the matter becomes white, and forms refin, or pitch refin. Galipot is diftilled in the large way in the provinces of France, and affords an oil, called huile-de-raze, or caulking pitch. The tar, which is the empyreumatic oil of this fubftance, is prepared with the branches and roots of the pine. The wood of this tree is laid in heaps, covered with turf, and fet on fire. The oil, difengaged by heat, not being capable of efcaping through the turf, is precipitated into a fhallow tub, by means of a channel, and is collected for fale by the name of tar.

8. Tacamahaca, gum elemi, gum animæ, are

are very little uſed: the tree that affords the fruit is not known. The gum elemi is obtained from a ſpecies of amiris; the oriental gum anime, or copal, whoſe origin is unknown, and the oxidental gum anime, or courbaril, which flows from the hymenea, a tree growing in South America, are uſed to make varniſhes.

9. Maſtic is in white farinaceous tears, of a weak ſmell; it flows from the turpentine tree, and the maſtic tree. It is uſed as an aſtringent and aromatic, and enters into the compoſition of drying varniſhes.

10. Gum ſandarac is in white tears, more tranſparent than maſtic. It is obtained from the juniper, between the bark and the wood. It is uſed to prevent the ſinking of ink into paper, whoſe external coating of ſize has been ſcraped off in making eraſures.

11. The reſin of guaicum, which is greeniſh, is uſed as a remedy for the gout. It is obtained from the guaicum tree, by inciſion.

12. The labdanum, or reſin of a ſpecies of ciſtus in Candia, is blackiſh. The country people collect it by means of a ſtaff, at the end of which are faſtened many leather thongs, which they gently ſtrike on the trees. They form it into cylindrical pieces, which are called labdanum in tortis. It is greatly adulterated by the addition of black ſand, and is uſed as an aſtringent.

 13. Dragons

13. Dragons blood is a red juice, obtained from the dracæna draco, and ſeveral other trees of the ſame kind. It comes to us in flat or round pieces, or in ſmall balls, wrapped up in leaves. It is uſed in medicine as an aſtringent.

CHAP. XIII.

Gum Reſins.

GUM reſins are juices mixed with reſin, and an extractive matter, which has been taken for a gummy ſubſtance. They never flow naturally from plants, but are extracted by inciſion, in the form of emulſive white, yellow, or red fluids, which dry more or leſs quickly. Water, ſpirit of wine, wine, or vinegar, diſſolve them only in part. They differ in the proportion of reſin and extract, and their analyſis affords various reſults: the ſpecies moſt neceſſary to be known are the following.

1. Olibanum conſiſts of yellow tranſparent tears, of a very diſagreeable ſmell. The tree which affords it is not known. By diſtillation, a ſmall quantity of eſſential oil, together with an acid ſpirit, are obtained, and the coaly reſidue, ariſing from the extractive

tractive part, is very conſiderable. It is uſed in medicine for fumigations.

2. Galbanum is a fat juice, of a brown yellow colour, and nauſeous ſmell. In Syria, Arabia, and at the Cape of Good Hope, it flows from inciſions made in a ferulaceous plant, named bubon galbanum by Linnæus. Diſtilled with a naked fire, it affords a blue eſſential oil, which afterwards becomes red; and alſo an acid ſpirit, with a ponderous empyreumatic oil. It is a very good diſcuſſive remedy, and is powerfully antiſpaſmodic.

3. Scammony is of a blackiſh grey colour, a ſtrong and diſagreeable ſmell, a bitter and very acrid taſte. The Aleppo ſcammony is diſtinguiſhed by its greater purity from that of Smyrna, which is ponderous, black, and mixed with foreign ſubſtances. It is extracted from the convolvulus ſcammonia of Linnæus. The root of this plant, cut in pieces and preſſed, affords a white juice, which is black when dried. The different ſpecimens of ſcammony contain various proportions of extract and reſin, and its medical effects differ accordingly. It is preſcribed as a purge, in the doſe of from 4 to 12 grains. Mixed with a ſweet extract, ſuch as that of liquorice, it forms the common diagredium; the juice of quinces is likewiſe uſed for this purpoſe. The common mode of adminiſtering it, is after previous trituration with ſugar and ſweet almonds.

4. Gum guttæ is yellow, reddiſh, without ſmell, and of a very acrid and corroſive taſte. It comes from Siam, China, and the iſland of Ceylon. It is extracted from a large tree, not much known, called by the natives, coddam pulli. It contains much reſin, which renders it ſtrongly purgative, in a doſe of from 4 to 6 grains. It ought not to be internally uſed, but with the greateſt caution.

5. Euphorbium is in yellow tears, which have the appearance of being worm-eaten; it has no ſmell. It flows from inciſions made in the euphorbium, which grows in Ethiopia, Lybia, and Mauritania. It contains a very acrid reſin, and is ſo ſtrongly purgative, that it is reckoned among poiſons. It is not uſed, unleſs externally, in caries.

6. Aſſafœtida is ſometimes in yellowiſh tears, but moſt commonly in loaves, formed of a number of pieces, agglutinated together. It has a very fetid ſmell of garlic, with a bitter and nauſeous taſte. It is extracted from the root of a ſpecies of ferula, which grows in the province of Choraſan, and is called aſſafœtida by Linnæus. The root of this plant is fleſhy and ſucculent. By expreſſion, it affords a white juice, of an abominable ſmell, which the Indians uſe as ſeaſoning for food, under the name of food of the gods. It is internally uſed as a powerful

ful antiſpaſmodic, and is applied externally as a diſcutient remedy.

7. Aloes is a juice of a deep red, or brown, and very bitter. It is diſtinguiſhed into three ſpecies; ſuccotrine aloes, hepatic aloes, and cabaline aloes: theſe differ only in their reſpective degrees of purity, the firſt being the beſt. A. De Juſſieu ſaw the preparation of the different kinds of aloes, from the leaf of the common aloe plant. Deep inciſions are made, from which the juice flows; this is decanted from its fecula, and thickened by the ſun's heat, in which ſtate it is packed in leather bags, under the denomination of ſuccotrine aloes. The juice obtained, by preſſure, from the leaves, after it is purified by repoſe, and dried, is the hepatic aloes. The ſame leaves, by ſtronger preſſure, afford a portion of juice, which, mixed with the dregs of the two foregoing, conſtitutes the hepatic aloes. The firſt ſort contains a much leſs quantity of reſin than the two laſt, which are more ſtrongly purgative. It is uſed in medicine as a draſtic purge, and is acknowledged to poſſeſs the property of exciting the menſtrual flux in women, or the hemorrhoids in men. It is much eſteemed as a good hydragogue.

8. Myrrh is brought to us in the form of reddiſh brilliant tears, of a ſtrong and rather agreeable ſmell, bitter taſte, and exhibiting white lines, of the form of a nail, in their

fracture. Some of theſe tears are intirely gummy, and inſipid. Myrrh comes from Egypt, and eſpecially from Arabia, in the country of the Troglodites. The plant from which it is extracted is not known. It contains much more extract than reſin. It is uſed as an excellent ſtomachic, antiſpaſmodic, and cordial remedy. Cartheuſer adviſes literary men, whoſe ſtomachs are delicate, to chew this, and ſwallow it with the ſaliva. It is uſed in ſurgery, either in powder, or diſſolved in ſpirit of wine, to cleanſe foul ulcers, and to ſtop the progreſs of caries.

9. Gum ammoniac ſometimes has the form of tears, white within, and yellow without, and is ſometimes in maſſes reſembling benzoin. They are eaſily diſtinguiſhed by their white colour and fetid ſmell. It is ſuſpected, from the admixture of ſeeds it contains, that this gum reſin, which comes from Africa, is extracted from an umbelliferous plant. The ſolubility of this ſubſtance in water, and in ſpirit of wine, and more particularly its inflammability, are properties in which it reſembles the reſinous extractive matters of Rouelle.

Gum ammoniac is medicinally uſed as a diſcuſſive remedy in obſtinate obſtructions; it is given in doſes of a few grains, in pills or emulſions, and likewiſe enters into the compoſition of many diſcuſſive and reſolvent plaſters.

10. The

10. The elaſtic gum, or caout-chouc, is a vegetable ſubſtance, whoſe nature cannot eaſily be determined; for though, in its combuſtible property, which is applied to the purpoſe of illumination in America, it ſeems to reſemble reſins, yet its elaſticity, ſoftneſs, and inſolubility in the menſtrua which diſſolve theſe laſt, are characters which ſhew that it greatly differs from them.

The tree which affords this ſubſtance grows in ſeveral parts of America. Horizontal inciſions are made quite through the bark; a white and fluid juice iſſues forth, which is applied, in ſucceſſive coats, on clay moulds, and dried by the ſun's heat. Various ſketches of deſigns are made on the ſurface with an iron tool. It is then expoſed to the ſmoke; and when perfectly dried, the clay is cruſhed and taken out. The bottles, and various utenſils of elaſtic gum, which are imported into Europe, are made in this manner.

Veſſels of elaſtic gum may be uſed to contain water, and various fluids which do not corrode its ſubſtance. If it be cut into pieces, and the newly-cut edges applied to each other, they adhere together with conſiderable force.

Elaſtic gum, ſet on fire, ſoftens, ſwells up, emits a fetid ſmell, and ſhrinks as it burns.

It is not ſoluble in water; and the action of

of ſaline matters on this ſubſtance is not known. Macquer, who attempted to diſſolve it in different menſtrua, clearly aſcertained, that it was not at all acted on by ſpirit of wine, as Meſſrs. De la Condamine and Freſneau had before aſſerted, in the Memoirs of the Academy for 1751, but that oils diſſolve it, by the aſſiſtance of heat. Nevertheleſs, as his intention was to liquefy, or diſſolve it in ſuch a manner, as that it might be uſed, and reſume all its properties, by the evaporation of the ſolvent, it became neceſſary for him to uſe a more volatile menſtruum than oils, which remain combined with the gum, and deprive it of its elaſticity. Highly rectified ether, which readily diſſolves this ſubſtance, and may be quickly evaporated, anſwers the purpoſe perfectly well. (See the Memoirs of the Academy for the year 1768.) And though this fluid is very expenſive, he thinks it may be advantageouſly uſed in making certain utenſils, ſuch as catheters, by ſucceſſively applying this ſolution on a mould of wax, till it is of the required thickneſs. When it is dry, the wax may be eaſily ſeparated, by immerſion in boiling water. The ſoftneſs and elaſticity of this inſtrument, renders it extremely uſeful for ſuch as are under the neceſſity of continually uſing it.

Such was the ſtate of our knowledge, reſpecting the elaſtic gum, when, in the month of

of April, 1781, Mr. Berniard, well known by the accuracy of his experiments, inferted, in the Journal de Phyfique, an excellent memoir concerning this fingular fubftance. This chemift concluded, from his experiments, that the elaftic gum is a peculiar kind of fat oil, coloured by matter which is foluble in fpirit of wine, and blackened by the fmoke, to which each coating is expofed to dry. Water does not at all change it; fpirit of wine deprives it of its colour, by boiling. The cauftic fixed alkali does not act upon it. Oil of vitriol reduces it to the ftate of coal, itfelf becoming black, and affuming the fmell and volatility of the fulphureous acid. The common nitrous acid acts in the fame manner on this fubftance as on cork, changing its colour to a yellow. Spirit of nitre very quickly deftroys it, but the muriatic acid does not affect it in the leaft. Rectified vitriolic ether did not diffolve it. This fact, as the author obferves, muft appear fingular, to all who are acquainted with the exactnefs and the veracity of Macquer. Nitrous ether diffolves it, and becomes yellow, affording, by evaporation, a tranfparent friable fubftance, which is foluble in fpirit of wine, and is in fact a true refin, formed, according to the author, by the action of the nitrous acid on the elaftic gum. The effential oil of lavender, and likewife thofe of afpic and of turnfole, diffolved

ſolved it by the help of a ſlight heat; but they formed gluey fluids, which daubed the hands, and conſequently were not applicable to any uſe. A ſolution of elaſtic gum, mixed with ſpirit of wine, depoſited white flocks, inſoluble in hot water, at the top of which they floated, and became white and ſolid, like wax, by cooling: it appeared to be a true concreſcible fat oil. Oil of camphor diſſolved elaſtic gum, by ſimple maceration. By evaporating this ſolution, the camphor was driven off, and an amber-coloured matter, of a firm conſiſtence, ſcarcely adheſive, remained in the capſule, and was found to be eaſily ſoluble in ſpirit of wine. Fat oils, boiled on elaſtic gum, diſſolve it, as does likewiſe wax. This ſubſtance does not melt by the heat of boiling water; but when expoſed to a greater heat, in a ſilver ſpoon, it is converted into a black thick oil, emits white vapours, and remains fat and adheſive, though expoſed to the air for ſeveral months, and does not recover the dryneſs and elaſticity in which its chief utility conſiſts. Laſtly, Mr. Berniard concluded his inquiries, by analyſing elaſtic gum with a naked fire. One ounce afforded a very ſmall quantity of phlegm; an oil, at firſt light and clear, but afterwards thick; and coloured and volatile alkali, in a quantity which he has not aſcertained. The coaly reſidue was ſimilar to that of reſins, and

and weighed 12 grains. This chemiſt attributes the volatile alkali to the ſoot with which the elaſtic gum is coloured.

We muſt obſerve, that this analyſis does not accurately aſcertain the nature of elaſtic gum, becauſe the action of acids on this ſubſtance does not reſemble that which they exhibit with fat oils, and which is much more rapid; becauſe cauſtic alkalis do not convert it into ſoap; becauſe it does not melt, but by a degree of heat much greater than is neceſſary to melt the moſt ſolid fat oils; becauſe no fat oil becomes dry and elaſtic, &c. &c. The author, beſides, in his fifteenth experiment, affirms, that this gum is compoſed of two diſtinct ſubſtances, which he does not exhibit; and he concludes, by conſidering it as the product of art. From all theſe reflections, and many others which may be added, concerning the experiments of Mr. Berniard, valuable as they are, we think, with him, that much remains to be done, to aſcertain the properties of this ſubſtance, and to enable us to decide reſpecting its nature.

CHAP.

CHAP. XIV.

Of the Pure Fecula of Vegetables.

THE juices of vegetables, elaborated in their veſſels, become thick, and are gradually depoſited on the ſurface of the fibres, which are by that means ſupported and augmented, or become accumulated, in a more or leſs ſolid form, in the organs of the plant. After having treated of the fluid parts of theſe organized ſubſtances, it is neceſſary to examine the ſubſtance of which their ſolids are compoſed. We are far from poſſeſſing an accurate knowledge of all the ſolid ſubſtances contained in vegetables; but it appears, that when treated by the proceſſes we are about to deſcribe, they are reducible into a dry, pulverulent, inſipid, white, grey, or variouſly coloured ſubſtance, inſoluble in cold water, and of an earthy appearance, called fecula.

To obtain this ſubſtance, a root, ſtem, leaf, or ſeed, is reduced to a pulp, by pounding. Succulent vegetables may be treated in this manner, without the addition of water; but in general water is added, to facilitate the ſeparation of the fibres, and to carry

carry off the divided and pulverized parts. The pulpy matter, by ſtrong preſſure, affords a turbid, white, or coloured fluid, which after ſome time depoſits, by ſtanding, a ſubſtance partly fibrous, and ſometimes pulverulent, which is the true fecula of vegetables. Some parts of vegetables appear to be intirely compoſed of this matter; ſuch as the ſeeds of gramineous and leguminous vegetables, tuberous roots, &c. Theſe parts in general afford the fineſt and moſt abundant fecula. As to the tender ſtems and leaves of vegetables, their more fibrous texture affords only a coarſe-coloured filamentous depoſition, diſtinguiſhed by the name of coarſe fecula. If theſe be well dried, pulverized and waſhed, the water carries off a much finer fecula, perfectly ſimilar to that of the tuberous roots and gramineous ſeeds. The chemiſt, therefore, makes no other diſtinction between theſe two kinds of fecula, than that the firſt is obtained from a leſs fibrous part, conſiſting, as it were, of cells, in which nature has depoſited dry or farinaceous mucilage; while the ſecond, being of a more fibrous texture, requires its organization to be deſtroyed by a more artificial proceſs.

All the vegetable parts of ſolids, ſtrictly ſpeaking, afford a kind of fecula; but we ſhall here more particularly ſpeak of ſuch as are prepared by art for food or medicine.

The

The fecula of bryony, potatoe, caſſava, ſago, ſalop, and ſtarch, are thoſe we ſhall particularly attend to.

1. To prepare the fecula of bryony, the firſt roots are deprived of their bark, raſped in pieces, and ſubmitted to the preſs. The juice is white, and depoſits a very fine fecula, from which, at the end of twenty-four hours, the liquid is decanted, and it is dried. As this fecula contains a certain quantity of extract, left by the juice, it is very acrid, and purges violently: by waſhing, it becomes finer, and whiter, but at the ſame time loſes its purgative virtue. This method of preparing the fecula of bryony affords but a very ſmall quantity, but a much greater may be obtained, by moiſtening, with water, the maſs remaining in the preſs, ſtraining this water through a hair ſieve, to ſeparate the groſſer fibres, and leaving it at reſt, and to depoſit its fecula, at which time the water is to be decanted off, and the powder dried. This laſt fecula is not purgative, like the former, becauſe it has been deprived of its extractive matter by the water. Mr. Baumé has obſerved, that the fecula of bryony is abſolutely the ſame as ſtarch, and may be made into hair powder, to the great ſaving of corn. The fecula of the roots of arum, and cornflag, are prepared in the ſame way for medical uſes.

2. Potatoes are among the moſt uſeful alimentary

alimentary ſubſtances, with reſpect to their abundance and fertility. They afford a large quantity of very fine white fecula, which, when boiled, is an excellent food. It is obtained by ſcraping the potatoes into a ſieve, and pouring thereon a large quantity of water. The fluid carries off the fineſt and moſt divided part of the fecula, which ſubſides by ſtanding. The water is decanted off, and the fecula, dried by a gentle heat, has the form of a very fine white powder. Mills, conſiſting of a kind of raſps, turning on cylinders, have been contrived, and are uſed to great advantage in preparing this fecula.

3. The Americans extract, from the root of a very acrid plant, called manioc, a mild nouriſhing fecula, which they call caſſava. They ſtrip the root, raſp it, and put it into a ſack of ruſhes, made in the form of a cone, and of a very open texture, which they ſuſpend to a ſtaff, placed acroſs two upright poſts. At the lower extremity of this ſack, they hang a heavy veſſel, which by its weight preſſes the root, and receives the juice which flows out, and is a moſt acrid and dangerous poiſon. When the fecula is well preſſed, and deprived of all its juice, it is dried in the ſmoke, ſifted, and then forms caſſava. This farina is ſpread on a hot plate of iron, and turned till both its ſurfaces acquire a reddiſh yellow colour, which denotes that it is ſufficiently baked. In this ſtate it is called

called caſſava bread. When the farina is heated in a veſſel, and agitated from time to time, it takes the form of grains, called couac. A very fine and mild fecula, called mouſſache, falls to the bottom of the expreſſed juice, and is uſed for paſtry.

4. Sago is a dry fecula, reduced into grains by the action of fire, and comes to us from the iſlands of Molucca, Java, and the Phillipines. It is obtained from a kind of palm, called landan, in the Moluccas. The trunk of this tree contains a ſweet pith, which the inhabitants take out after having ſplit the wood; they then bruiſe it, and put it into a kind of cone, or funnel, made of bark, and pour on a large quantity of water. This fluid carries with it, through the ſieve, the fineſt and whiteſt part of the pith, the fibrous part remaining behind. The water is received into pots, and gradually depoſits the fecula. The clear water is then decanted, and the depoſited matter is paſſed through perforated plates, which give it the form of ſmall grains. The red colour on their ſurface riſes from the action of fire, uſed in the drying. Theſe grains, or ſago, become ſoft and tranſparent in boiling water, and form, with milk or ſoup, a light and agreeable liquid, which is ſtrongly recommended in phthiſical diſorders.

5. Salep, ſalop, ſalab, &c. is the root of a ſpecies of orchis, prepared by the orien-

tals.

tals. They ſelect the fineſt bulbs of this plant, which they peel, and boil, after previouſly ſoaking them in cold water. They are then ſtrung, and dried in the air. M. Jean Moult deſcribes another proceſs for preparing ſalop, which may be uſed with every kind of orchis. The roots, either dry or under water, are rubbed with a bruſh, to take off the external pellicle; after which, by drying in an oven, they become very hard and tranſparent. Theſe are very eaſily reduced into powder, which, with hot water, forms a nouriſhing jelly, much praiſed by Geoffroy, in all diſorders ariſing from an acrid ſtate of the lymph, and eſpecially in conſumptions, and the bilious dyſentery.

C H A P. XV.

Concerning the Farina, and Starch of Corn.

STARCH, properly ſpeaking, is a fecula abſolutely ſimilar to the foregoing; but as the farina of corn, of which it is a conſtituent part, is one of the moſt important ſubſtances that come under the examination of the chemiſt, we ſhall treat more fully on this than on the other fecula.

The ſubſtance called flour, is in general

 dry,

dry, friable, inſipid, capable of acquiring taſte and digeſtibility, by the action of fire, and compoſed of ſeveral ſubſtances eaſily ſeparable from each other. It exiſts in the ſeeds of gramineous plants, more eſpecially wheat, rye, barley, oats, rice, buckwheat, &c. Leguminous plants likewiſe appear to contain a compound analogous to flour; but the flour of wheat only can be ſaid truly to poſſeſs the requiſite properties, becauſe it is the only farina in which the different ſubſtances are duly proportioned to each other. Though the economical uſe of the flour of wheat, as the principal article of nouriſhment, has been eſtabliſhed from time immemorial, it is but lately that chemiſts have began to examine it. Meſſrs. Beccarri, an Italian phyſician, and Keſſel Meyer, in Germany, are the firſt chemiſts who endeavoured to ſeparate the different ſubſtances contained in flour. Meſſrs. Rouelle, Spielman, Malouin, Parmentier, Poulletier de la Salle, and Macquer, continued and carried the experiments of theſe philoſophers much farther. Mr. Parmentier, eſpecially, has proſecuted this inquiry with uncommon zeal and activity. His reſearches into the nature of alimentary ſubſtances, the component parts of flour, the different ſpecies of fecula, and on all nutrative vegetables in general, are, without doubt, the moſt complete and exact of any that have been made in this way.

Water is an agent of the greateſt utility, and leaſt capable of altering the ſeveral matters it takes up, or ſeparates, in the order of their ſolubility. This fluid is uſed, with the greateſt ſucceſs, to obtain the different ſubſtances of which wheat flour is compoſed. To perform this true analyſis, a paſte is made with flour and water, and kneaded in a veſſel of water, underneath a ſtream from a cock; the water carries off a very fine white powder, and the kneading muſt be continued till this fluid paſſes off clear. The flour is then found to be ſeparated into three ſubſtances; a greyiſh and elaſtic matter remaining in the hand, which has been called the glutinous, or vegeto-animal part, on account of its properties; a white powder, depoſited by the water, which is the fecula, or ſtarch; and a ſubſtance, held in ſolution by the water, which appears to be a kind of mucilaginous extract. We ſhall examine the properties of each of theſe three ſubſtances in order.

§ I. Concerning the Glutinous Part of Wheat.

The glutinous part, is a tenacious, ductile, elaſtic matter, of a whitiſh grey colour. When drawn out, it extends about twenty times its length before it breaks, and appears as if compoſed of fibres, or filaments, placed

beſide each other, according to the direction in which it has been drawn. If the force ceaſes, it reſumes its original form by its elaſticity. By drawing it out, in different directions, it may be made ſo thin, that its poliſhed ſurface reſembles the texture of animal membranes. In this ſtate it adheres ſtrongly to dry bodies, and forms a very tenacious glue, which was uſed by ſome perſons to join broken china, long before chemiſts found the means of obtaining it in large quantities. Mr. Beccari has obſerved, that the proportion of glutinous matter is from a fifth, to a third, and more, in flour of the beſt quality; he has likewiſe obſerved, that this quantity varies in different ſeaſons, and according to the nature of the corn.

The ſmell of the glutinous matter is faint, and reſembles that of mucilage; expoſed to a fire capable of ſuddenly drying it, it ſwells up prodigiouſly. In a dry air, or mild heat, it dries very well. It is then ſemi-tranſparent, and hard, like glue, and ſnaps ſhort like that ſubſtance.

If in this ſtate it be placed on burning coals, or applied to the flame of a candle, it exhibits all the characters of an animal ſubſtance; it decrepitates, ſwells, liquifies, curls up, and burns like a feather, or a piece of horn, emitting, at the ſæme time, a ſtrong and fetid ſmell. By diſtillation, it affords, like animal ſubſtances, alkaline ſpirit, con-

crete

crete volatile alkali, or ammoniacal chalk, and an empyreumatic oil. Its coal is very difficultly incinerated, and does not contain fixed alkali.

Freſh gluten, expoſed to a hot and dry air, becomes changed, and putrifies abſolutely in the ſame manner as animal ſubſtances. When it retains a ſmall quantity of ſtarch, this laſt paſſing to the acid fermentation retards and modifies the putrid fermentation, and converts the ſubſtance into a ſtate nearly ſimilar to that of cheeſe. Rouelle the younger prepared a cheeſe with the gluten, which ſingularly reſembled in its ſmell and taſte, that of Gruyeres, or of Holland.

Water does not at all diſſolve this glutinous matter. By boiling in this fluid it becomes ſolid, loſes its extenſibility and adheſive quality, but does not acquire either taſte or ſolubility in the ſaliva. Neverthleſs, we muſt obſerve, that the gluten owes its elaſticity and ſolidity to the water which formed the paſte. In fact, this vegeto-animal portion, though capable of becoming ſolid and elaſtic, is pulverulent, and without coheſion in the flour; but as ſoon as water is added, its particles abſorb the fluid, and adhere together, forming the elaſtic ſubſtance called gluten. Water, therefore, contributes greatly to the formation of this ſubſtance, and it

may perhaps be conſidered as a compound, ſaturated with, and incapable of abſorbing a larger quantity of water. This is ſo true, that it abſolutely loſes its adheſion and elaſtic properties by drying.

Moſt ſaline ſubſtances act more or leſs efficaciouſly on the gluten. The cauſtic fixed alkalis in the fluid ſtate diſſolve it by boiling. This ſolution is turbid, and depoſits, by the addition of acids, a gluten which is not elaſtic.

The mineral acids diſſolve the gluten. The nitrous acid diſſolves it with great activity, and Mr. Berthollet has obſerved, that this acid diſengages mephitis, as it does from animal ſubſtances. When this elaſtic fluid has been emitted, the ſolution affords a large quantity of nitrous gas, and becomes of a yellow colour. By evaporation it affords cryſtals of the acid of ſugar. The vitriolic and marine acids form brown or violet ſolutions of this ſubſtance, from which a kind of oily matter ſeparates; the gluten being truly decompoſed. Mr. Poulletier, who has made many experiments on this ſubſtance, has diſcovered, that ammoniacal ſalts may be obtained from theſe combinations, diſſolved in water, or ſpirit of wine, and evaporated in the open air.

From theſe facts, it follows, that this ſubſtance is totally different from all thoſe hitherto known in vegetables, and that in

many

many of its characters it resembles the fibrous part of the blood. It is to this gluten that wheat flour owes its property of forming a very adhesive paste with water, and the facility with which it rises in leaven. The gluten does not appear to exist, at least in any considerable quantity, in other farina, such as that of rye, barley, buckwheat, rice, &c.; all which form solid, opake pastes, scarcely ductile, easily broken, and which do not ferment when exposed to the temperature by which that process is effected in wheat paste. The presence of the gluten appears therefore to be necessary for the production of good bread.

Mr. Berthollet thinks that this glutinous substance contains phosphoric salt, like animal matters, and that this is the cause of the difficulty with which its charcoal is incinerated. Rouelle the younger found a glutinous substance analogous to that of wheat in the green fecula of plants, which afford volatile alkalis and empyreumatic oil, as does the vegeto-animal substance here treated of.

§ II. Concerning the Starch of Wheat.

Starch, or the amylaceous fecula, composes the greater part of flour; it is the white substance which subsides from the water used in obtaining the pure gluten. This

This ſubſtance is very fine, and ſoft to the touch; its taſte is ſcarcely ſenſible. Its colour is of a grey and dirty white, when extracted by the proceſs we have deſcribed; but the ſtarch-makers render it extremely white by ſuffering it to remain in the water for a time, after it has become acid. It appears from the experiment of Mr. Poulletier, that the fermentation which takes place in this fluid, whitens and purifies the ſtarch by attenuating, and even deſtroying the extractive mucilaginous ſubſtance with which it is vitiated at firſt. Starch, chemically conſidered, is a mucilage of a peculiar nature. This mucilage, which has been improperly conſidered as an earth by ſome chemiſts, differs greatly from the glutinous part. It burns without emitting an empyreumatic ſmell. By diſtillation with a naked fire, it affords an acid phlegm, of a brown colour, and a very thick empyreumatic oil towards the end. Its coal is eaſily reduced to aſhes, which contain fixed alkali.

Starch is not ſoluble in cold water, but when boiled in water, it forms a kind of glue, that, when expoſed to a moiſt air, gradually loſes its conſiſtence, ferments, becomes ſour, and at laſt mouldy.

The nitrous acid produces the acid of ſugar with this fecula, which is perfectly ſimilar to thoſe we have treated of in the foregoing chapter.

As

As ſtarch forms the greateſt part of flour, it cannot be doubted, but that it is the principal alimentary ſubſtance contained in flour, and in bread.

§ III. Concerning the Mucilaginous Extractive Part of Flour.

By evaporating the pure water with which the paſte was waſhed, and from which ſtarch had been depoſited, Mr. Poulletier obtained a viſcous gluey ſubſtance of a brown yellow colour, and ſlightly ſaccharine taſte. This ſubſtance, denominated by its diſcoverer the mucoſo-ſaccharine matter, exhibited all the phenomena of ſugar in its combuſtion and diſtillation. It is this which excites the acid fermentation in the water that floats above the ſtarch; for, as Macquer well obſerves, the latter is not at all ſoluble in cold water.

The mucoſo-ſaccharine matter exiſts in a very ſmall proportion in wheat corn, but may pethaps be more abundant in other kinds of flour.

It cannot be doubted, notwithſtanding the ſmall quantity of this ſubſtance contained in wheat corn, but that it is principally concerned in the fermentation by which paſte is leavened. This inteſtine motion, ſo neceſſary in the making of good bread, is not yet well underſtood. It may perhaps conſiſt

ſiſt in the commencement of fermentation, which is putrid in the gluten, acid in the ſtarch, and perhaps ſpiritous in the mucoſo-ſaccharine matter; and from theſe three incipient fermentations mutually impeding each other, the lighter compound, which by baking forms bread, may probably ariſe. At all events, it is certain, that the three ſubſtances we ſpeak of are ſo combined and altered in bread, that they can no longer be ſeparated. The action of heat is ſufficient, without fermentation, to produce this intimate combination; for unleavened bread, according to Malouin and Poulletier, does not afford the glutinous matter.

From the foregoing facts we ſee, how greatly other kinds of flour differ from that of wheat, and ſtill more thoſe leguminous and farinaceous ſeeds, ſuch as beans, peaſe, cheſnuts, &c. are far from poſſeſſing the qualities neceſſary to make good bread.

CHAP. XVI.

Concerning Vegetable Colouring Matters, and their Application to the Art of Dying.

VEgetables contain colouring matters in all their organs. Theſe parts differ greatly from each other; for a vegetable ſubſtance, which

which has no apparent colour, often aſſumes a very evident tinge, by peculiar menſtruums. The art of dying, all the proceſſes of which are abſolutely chemical, is founded on the ſolubility of colouring matters in different menſtrua, the method of applying them to ſubſtances propoſed to be dyed, and of rendering them fixed. In treating of the properties of each colouring matter, we ſhall have occaſion to ſpeak of the principles of this important art, which is excellently treated of in the works of Hellot, Macquer, Le Pileur d'Apligny, Hecquet d'Orval, and the Abbé Mazeas.

The colouring matter of vegetables properly ſo called, is not yet well known. Rouelle ſuppoſed that the colouring matter, which is ſo abundant in the vegetable kingdom, was analogous to the gluten of flour; but it is certain, that this matter preſents different chemical characters, according to the baſe with which it is united. When, therefore, it is ſaid, that a colour is extractive, reſinous, &c. the terms apply rather to the baſe, than to the colouring matter. The true colouring matter of vegetables uſed in the arts, is doubtleſs of a very ſubtle nature, and is perhaps as diviſible as the principle of ſmell. It may even be ſuppoſed, that it conſiſts only in a peculiar modification of the ſolid and liquid parts of vegetables. It is neceſſary to repeat in this place, that the colour of

of vegetables is for the moſt part produced by the contact of light; but the manner in which light produces this effect, is a problem not yet ſolved. However this may be, as it is impoſſible to ſeparate the colouring matter intirely from the vegetable baſe it adheres to, theſe two ſubſtances are uſually taken together for the colouring matter.

No chemiſt has more accurately diſtinguiſhed the vegetable colouring matters, conſidered with reſpect to the art of dying, than Macquer; and his theory concerning the applying and fixing theſe colours to ſubſtances intended to be dyed, muſt be admitted as highly ſatisfactory. As it is our intention to connect this theory of dying with the hiſtory of the chemical properties of vegetable colouring matters, we ſhall conſider them in the ſame point of view.

1. A great number of vegetable colouring matters, which are of an extractive or ſaponaceous nature, are readily diſſolved in water. Baſtard rocket, madder, logwood, redwood, and Braſil wood, afford yellow or red colours of this kind. It may be eaſily conceived that ſubſtances tinged with theſe matters, readily give out their colour to water; and it is therefore found neceſſary, in order to render them durable, to make uſe of ſome additional ſubſtance capable of decompoſing and fixing them; as for example, crude tartar, alum, and other ſalts. Theſe

ſalts

ſalts are called corroſives. A diſengaged acid would produce the ſame effects, but it would alter the colouring matter. The portion of ſuperabundant acid of the alum unites with the alkali of the colouring ſaponaceous extract, and cauſes the reſinous part, which is then inſoluble in water, to be precipitated on the ſubſtance intended to be dyed. However, this colouring portion, rendered inſoluble by the alum, or the corroſive, is of two kinds; the firſt is very ſolid, and reſiſts the air, ſoaps, and all the liquors which dyers call proofs. This kind of colour is called a good or ſtrong dye. The other is changed by the air, and eſpecially by the action of the proof liquors: It is called a falſe dye. To diſcover the nature of theſe colours, and the duration of dyes in general, Mr. Berthollet propoſes the uſe of the dephlogiſticated or aerated muriatic acid, which in a very ſhort time, by its exceſs of the oxyginous principle, produces the ſame effect as the pure air of the atmoſphere would effect in a much longer ſpace of time. The quantity of acid required to diſcolour and intirely bleach any dyed ſtuff, as well as the time required for this purpoſe, may ſerve to determine the ſolidity and duration of colours.

It is obſervable that wool takes the dye better than any other ſubſtance; and that ſilk, cotton, and flax, in the order we have mentioned

tioned them, are dyed with more difficulty, and retain the colouring ſubſtance more weakly.

Writers on the art of dying, hold different opinions reſpecting the manner in which the colouring parts apply themſelves to the ſubſtances expoſed to their contact. Many have ſuppoſed that this application takes place only in proportion to the number and magnitude of the pores in the various ſubſtances; and that wool takes the dye better than ſilk or thread, becauſe its pores are more open and numerous. But Macquer thinks, that the greater or leſs facility with which the colour is applied, depends on the reſpective nature of the colouring parts and the ſubſtance propoſed to be dyed; and that the art of dying is truly an external tinge or painting, which ſucceeds and laſts by virtue of an affinity and intimate union between the colour and the dyed ſubſtance. This celebrated chemiſt adopted the opinion here recited, in conſequence of the numerous experiments for which this art is greatly indebted to him.

2. Another kind of colouring matter ſeems to be compoſed of ſaponaceous extract and reſin. Macquer calls them reſino-terreſtrial matters. When theſe matters are boiled in water, the reſinous ſubſtance they contain melts, and is diſperſed in the fluid by the aſſiſtance of heat, and by virtue of the diſſolved ſaponaceous portion; but it precipitates in pro-

proportion as the decoction or bath becomes cold. Consequently, when wool, or any other substance is plunged in a decoction of this nature, the resin separates by cooling, and applies itself without any other preparation; and as it is not soluble in water, it forms a lasting dye. Colouring matters of this class are obtained from almost all astringent vegetables, such as the husks of nuts, roots of walnut-tree; or of dock, sumach, bark of alder, sandal-wood, &c. These colours are all yellow, and are called root colours by the dyers. They generally serve to form a very good ground, on which other more brilliant colours may be applied. It may be observed, that colouring ingredients, which require no preparation either in the bath, or in the stuff to be dyed, are more easily applied to use than others.

3. The colouring principle of many other substances resides in a purely resinous matter, insoluble in water, and some not even in spirit of wine; but they all are soluble in alkalis, which convert them into a kind of soaps, soluble in water. The principal colours of this nature employed in dying are the following:

A. The annatto, a kind of fecula, obtained by maceration of the seeds of the urucu putrefied in water. This fecula deposited during the putrefaction, is first red, and in process of time becomes of a brick

dust

dust colour. The paste is mixed in water with the cendres gravelees, shortly to be described, and forms a bath, wherein the stuffs intended to be dyed are plunged. A gold, or orange yellow colour, of considerable beauty, is deposited without the assistance of a corrosive.

B. The flower of carthamus, or bastard saffron, affords a very fine red colour, by the same process. It contains two distinct colouring parts; the one purely extractive and soluble in water, the other resinous. In order to obtain the latter, the soluble part of the carthamus must first be carefully washed away. The remainder is mixed with the cendres gravelees, or salt of soda; and the mixture being lixiviated, forms a bath. But as the alkali alters the colour, and renders it dull, the dyed stuff is plunged in water rendered acid by lemon juice; the acid seizes the alkali, and leaves the colouring matter, which it enlivens, and causes to become red. A coloured fecula is obtained by a similar process, which, mixed with briançon chalk in powder, composes the rouge used by the ladies.

C. Archil is a paste prepared with mosses and lichen macerated in urine with lime: The latter disengages the volatile alkali, which developes the red colour. Archil mixed with water, affords a dye without any other preparation; with alkalis, it strikes a violet

a violet colour; but this is a falſe dye, which changes in the air, and becomes yellow by the action of acids.

D. Indigo, which is of a deep violet blue, of a coppery tinge, is a fecula prepared at St. Domingo, and in the Antilles, &c. by macerating the ſtalks of the anillo, or indigo plant, in ſtone troughs, with water. The water becomes blue, and after ſtrong agitation the fecula precipitates. The indigo ſeparated from the water, is put into cloths to drain, and after being dried in ſmall wooden boxes, it is broken into pieces. It is eſteemed good when it floats on water, and burns intirely away on a red-hot ſhovel. The colouring matter is extracted by alkalis, and applied, without any other preparation, to the ſtuffs. It cannot be brightened by acids, becauſe they change its colour.

4. Certain colouring ſubſtances are ſoluble in oils. Alkanet, or the red root of a kind of bugloſs, communicates its colour to oil. Spirit of wine likewiſe diſſolves ſeveral colouring matters: green feculæ diſſolve in this menſtruum, as well as in oil. It may eaſily be conceived, that theſe colours are not uſed in dying, becauſe the liquids neceſſary to extract them cannot be employed.

Such are the principal circumſtances in which our knowledge of vegetable colours conſiſts. Every immediate principle of vegetables may conſtitute the baſe of theſe co-

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louring parts, ſince they are found of ſaponaceous, reſinous, and extractive kinds. Some even appear to be of the nature of fat oils, being inſoluble in water, or ardent ſpirit, though they readily combine with alkalis. Laſtly, there are ſome which are analagous to the glutinous part, according to Rouelle.

There is every reaſon to think, that future inquiries, if ſkilfully made, will diſcover many other properties of theſe ſubſtances, which greatly abound in vegetables, and that they will contribute to the improvement of the art of dying; an art to which chemiſtry is well adapted to render the moſt important ſervices.

C H A P. XVII.

Concerning the Analyſis of Plants, by deſtructive Diſtillation, or a naked Fire.

AFTER having examined all the ſubſtances which may be obtained from plants, by ſimple methods, which are incapable of changing them; and after having conſidered theſe matters as the immediate principles of organized ſubſtances, it is neceſſary

ceſſary to attend to the alterations they ſuffer when expoſed to heat.

The ancient chemiſts were acquainted with no other method of analyſing vegetables, and all their reſearches into the nature of theſe bodies, conſiſted in determining how much ſpirit, oil, and volatile ſalt they afforded by diſtillation. This method is at preſent no longer eſteemed, as it is known, that moſt plants afford nearly the ſame products; and the diſtillation of a great number of different vegetables, made by chemiſts, in other reſpects deſerving the eſteem of the public, has only ſerved to undeceive us. In fact, how can it be imagined, that the action of fire, exerted on all the different principles in a vegetable ſubſtance, ſuch as extract, mucilage, oil, reſin, ſalt, gluten, &c. which decompoſes each of theſe principles in a peculiar manner, can afford any knowledge reſpecting their nature and quantity; more eſpecially when it is obſerved, that the products of theſe ſeveral decompoſitions unite together, and produce new ſubſtances, ſuch as did not exiſt in the vegetable under examination? The analyſis of vegetables, by diſtillation, is therefore complex and fallacious.

However, as none of the methods which art is in poſſeſſion of, ought to be neglected, in the chemical examination of any ſubſtance, we may have occaſional recourſe to this analyſis,

lyſis, always carefully obſerving, that it is not too much to be depended on. It ſometimes happens, that when the effects of aqueous, ſpiritous, and oily menſtrua, on any ſubſtance, are compared with the alterations produced in it by fire, theſe laſt confirm the deductions made from the action of the ſolvents, and by the products of the diſtillation, indicate the ſubſtances contained in greater or leſs quantities, the nature of its ſalts, &c. But to make valuable deductions from the analyſis by fire, it is neceſſary, 1. To be well acquainted with the action of fire, on each immediate or proximate principle, ſuch as extract, mucilage, ſaline matter, oily juices, the fluid, or ſolid part, &c. 2. To compare the products, afforded by diſtillation, of the whole vegetable, with thoſe uſually afforded by the proximate principles, treated in the ſame manner. 3. To analyze the vegetable by menſtruums, in order to obtain its proximate principles, and to make uſeful inductions from the alterations it has ſuſtained by fire.

The proceſs of diſtilling vegetables by a naked fire, is very eaſy and ſimple. A given quantity, of a dry vegetable, is put into a glaſs, or earthen retort, ſo as to fill it not more than half or two thirds; the retort is then placed in a reverbaratory furnace, and a receiver of a proper ſize adapted. It was formerly ſuppoſed neceſſary to uſe a receiver,

perforated

perforated with a ſmall hole, to give vent to the air ſaid to be diſengaged from vegetables, and tending to burſt the veſſels. But it is at preſent known, that the aeriform fluid, which eſcapes from theſe bodies during diſtillation, is ſcarcely ever air, but conſiſts of cretaceous acid and inflammable gas. Now, as theſe elaſtic fluids are products of the vegetable compound, by fire, as well as the phlegm, the oils, and the volatile ſalts, it is equally neceſſary to collect them. For this purpoſe, a perforated receiver, communicating with an inverted glaſs veſſel, filled with water or mercury, may be uſed. By this means, the liquid products are collected in the receiver, and the aeriform products under glaſs veſſels, placed on the ſhelf of a pneumato-chemical apparatus. When the ſubſtance diſtilled affords a concrete ſalt, an adapter, or long glaſs veſſel, is fixed between the retort and the receiver, in order that the ſublimation may be made on its internal ſurface. The operation is begun, by placing a few pieces of lighted charcoal beneath the retort, and the fire is gradually increaſed till the veſſel is red-hot, and nothing more comes over. After the whole has become cold, the apparatus is unluted, to examine each of the products obtained.

Though the diſtillation of vegetables never affords products which may be conſidered as principles of the plant, yet theſe products

differ conſiderably from each other, and require to be carefully diſtinguiſhed.

The firſt product which comes over, is an aqueous liquor, containing certain odorous and ſaline principles. As the diſtillation advances, the colour and ſaline properties of this phlegm become ſtronger. It is ſucceeded by an oil, whoſe colour, conſiſtence, and weight, gradually increaſe. From ſome vegetables, a light and fluid oil is obtained; but from others, a ponderous oil, capable of becoming concrete. The ſmell of this oil is always ſtrong, and empyreumatic. During the time it comes over, a quantity of elaſtic fluid is diſengaged, which conſiſts either of the cretaceous acid, or inflammable gas, but moſt commonly of a mixture of both. At this period it is that the volatile alkali ſublimes, when the vegetable is of ſuch a nature as to afford it. When all theſe ſubſtances are paſt, the reſidue of the vegetable is of the nature of coal. We ſhall now proceed to examine more particularly into the nature and origin of each of theſe products.

The phlegm is produced from the water that enters into the compoſition of the vegetable, and partly from the water of vegetation, eſpecially when the matter is not intirely dry; ſo that its quantity is greater or leſs on this account. The phlegm is coloured red, by a ſmall quantity of oily matter

ter which riſes, and is uſually rendered ſaponaceous, by the ſalt contained in the fluid. The ſaline matter is moſt commonly acid; for which reaſon the phlegm uſually reddens ſyrup of violets, and cauſes an effervеſcence with cretaceous alkalis. This acid ariſes from the mucilage, and the oil. But the phlegm is ſometimes alkaline, as happens when nitrous or cruciferous plants, or emulſive and farinaceous ſeeds, are diſtilled; and it is often ammoniacal, becauſe the volatile alkali ſucceeds the acid, and combines with it. This fact may be aſcertained by the addition of a ſmall quantity of quicklime, or alkali, by which a ſtrong ſmell of votile alkali will be produced, when ammoniacal ſalt is preſent. Though the acids of vegetables do not appear to be all of the ſame nature, thoſe which are obtained, in their diſſolution, exhibit the ſame external characters: but they have not yet been ſufficiently examined to aſcertain their properties with any degree of accuracy. The oils obtained from vegetables in this method, are all ſtrong-ſmelling, highly-coloured, and poſſeſs nearly the ſame properties. Thoſe parts of vegetables which contain a large quantity of theſe inflammable fluids, ſuch as the emulſive ſeeds, afford a large quantity of oil in their analyſis. Odoriferous plants afford an oil, which, at the beginning, ſlightly partakes of their peculiar ſmell, but quick-

ly aſſumes the characters of other oils of this kind, namely, colour, weight, and an empyreumatic ſmell. All theſe fluids are very inflammable; the nitrous acid ſets them on fire, and they are ſoluble in ſpirit of wine. They may all, by rectification, be rendered very fluid, light, and colourleſs, and be converted into the ſtate of etherial or eſſential oils.

The volatile ſalt, or ammoniacal chalk, is only obtained from certain vegetables; but it is not true, as ſome chemiſts have affirmed, that it is afforded only by the cruciferous plants. All plants in general, which contain a certain quantity of glutinous or vegeto-animal matter, afford more or leſs of volatile alkali, by virtue of the mephitis, ſhewn by Mr. Berthollet to exiſt in this vegetable principle. It is very ſeldom, however, that any conſiderable quantity is obtained in the concrete ſtate, as it is uſually diſſolved in the laſt portions of the phlegm. This ſalt is produced by the union of the mephitis with the inflammable gas of the oil, and for this reaſon it moſt commonly paſſes over towards the end of the diſtillation. It even ſeems, that the volatile alkali, which riſes with the phlegm in the analyſis of certain plants, ſuch as the cruciferous plants, poppy, rue, &c. is always the product of a new combination; ſince Rouelle the younger has ſhewn, that the plants them-

themſelves do not contain it in their natural ſtate.

The elaſtic fluids, diſengaged during the diſtillation of vegetables, appear to depend on the nature of the vegetable. A plant, which contains a large quantity of oily combuſtible fluid, affords inflammable gas. Mucilages, on the contrary, afford cretaceous acid. We have obſerved, at the article of the acid of ſugar, that Bergman and Fontana obtained a large quantity of cretaceous acid from that ſubſtance, and that the latter chemiſt thinks, that vegetable acids are for the moſt part compoſed of it. It is not, therefore, to be wondered, that mucilages, in which Bergman diſcovered the ſame acid as exiſts in ſugar, ſhould afford cretaceous acid. Laſtly, there are ſome vegetable matters which afford atmoſpheric mephitis. Theſe aeriform fluids are not extracted till near the end of the diſtillation, when the vegetable becomes intirely decompoſed. Hales, who was not acquainted with their nature, obſerved, that the quantity of air diſengaged during the diſtillation of vegetables is greater, the more ſolid they are; whence he concluded, that this element was the cementing principle and cauſe of ſolidity in bodies. It is eaſy to form a proper opinion of this hypotheſis, from what has been already ſaid.

CHAP.

CHAP. XVIII.

Of Vegetable Coal, or Charcoal.

CHARCOAL is the black residue of vegetables, which have suffered a complete decomposition of their volatile principles, in closed vessels. The property of affording charcoal is only observed in such organic substances as contain the combustible matter called oil. The formation of coal was formerly attributed, exclusively, to the decomposition of this last substance; but we begin to perceive, that the carbonaceous matter exists, ready formed, in vegetables, and that the action of fire merely separates the volatile principles.

Charcoal in general is black, brittle, sonorous, and light; it retains the form of the vegetable, provided its texture has been consistent, and the quantity of fluid not very great. If, on the contrary, a soft and succulent plant be decomposed, the volatile matters, during their disengagement, destroy the organic texture, and afford a friable coal, which does not possess the figure of the vegetable. The quantities of coal vary according to the solidity and texture of the vegetable.

vegetable. Wood affords more than herbs; gums more than resins; and these last, more than fluid oils. Each vegetable substance appears to contain it, in different quantities, if we consider charcoal as one of the immediate principles of this kingdom.

Charcoal is a substance which possesses very singular properties, for the most part little known. Though it is of the greatest importance in chemistry, and exhibits phenomena of the most singular kind, no chemist has yet attempted to discover its nature by a connected series of inquiries. Stahl, who attended more particularly to this substance than any other chemist, considers it as the principal repository of phlogiston. The knowledge we possess concerning the properties of charcoal, is almost intirely confined to its economical uses; and the labours of philosophers exhibit nothing which can be called complete respecting it. The physical properties of charcoal differ according to the state and nature of the vegetable used in its formation; it is sometimes hard, and, as we have observed, retains part of the organization of the vegetable: other specimens are friable, and pulverulent. Pure oils afford a coal, in very fine particles, known by the name of lamp-black. Its weight varies according to circumstances. When well made, it has neither taste nor smell in any sensible degree. Its colour is also subject

ject to variation, and is of a black more or less deep, either shining or dull. But the most important inquiry, respecting this product of fire, relates to its chemical principles.

Charcoal, exposed to the most violent heat, in closed vessels, is not in the least altered. Heated in the pneumato-chemical apparatus, it does not afford inflammable gas, unless water be present. A strong fire reduces it into vapour. When heated with contact of air, it burns, and is reduced to ashes, but with peculiar phenomena, which it is essentially necessary to distinguish carefully from those of other combustible matters. When set on fire, it becomes red, and burns with a white flame, which is more considerable, the larger the mass. It emits no kind of smoke, but is converted into the elastic fluid, cretaceous acid, which, according to M. Lavoisier, is a combination of the carbonaceous and oxyginous principles, the latter forming three-fourths of the whole. In this manner the charcoal becomes gradually consumed, and leaves only ashes, more or less white, partly saline, and partly earthy. The different charcoals vary in their inflammability; a distinction which more particularly ascertains their utility in the arts. Some burn with flame, and are very quickly consumed; others do not take fire but with difficulty, burn slowly, and are not reduced

to

to aſhes but after a long ignition. There are ſome, as for example, the charcoal of oils, which do not burn but with the greateſt difficulty. This character ſeems to depend on the adherence of the carbonaceous principle to the fixed ſalts of vegetables.

Charcoal, expoſed to the air, attracts humidity, probably becauſe it is very porous, and perhaps likewiſe by virtue of the ſalts it contains, though they be not in a diſengaged ſtate. When moiſtened, it affords inflammable air, by heat, which ariſes from the decompoſition of the water; for when that fluid is paſſed in vapour through an earthen tube, filled with red-hot charcoal, theſe two bodies are converted into inflammable gas, and aeriform cretaceous acid. The reſidue is a ſmall quantity of aſhes. Rouelle has obſerved, that fixed alkali diſſolves a conſiderable quantity of charcoal by fuſion.

The vitriolic acid, ſtrongly heated with charcoal, in powder, is decompoſed by that combuſtible ſubſtance, which has a ſtronger affinity than ſulphur with the oxyginous principle.

The nitrous acid is much more rapidly decompoſed by charcoal. Dr. Prieſtley obſerved, that much nitrous gas is produced in this mixture. Macquer found, that the nitrous acid very ſenſibly efferveſces with this body, by the aſſiſtance of heat. Mr. Prouſt has ſucceeded in ſetting fire to charcoal,

coal, by the addition of a nitrous acid, weighing one ounce four drachms and twenty-three grains, in a bottle which held an ounce of diſtilled water. The novelty and importance of his experiments are ſuch, that I ſhall quote his own words, extracted from his obſervations on pyrophori made without alum, &c. inſerted in the Journal de Medicine for July 1778.

"Coal from the extract of carthamus, re-
"duced to powder, and recently calcined,
"detonated very ſtrongly with the nitrous
"acid; and the rapidity with which the
"mixture took fire, threw up the powder
"in the form of a very beautiful fire-work.
"I calcined very fine powder of common
"charcoal, and the detonation ſucceeded
"very well.

"I introduced about a drachm of the
"powder of charcoal into a very dry glaſs
"retort; I then poured in about a drachm
"of nitrous acid, which had no ſooner
"reached the bottom of the retort, than
"the detonation took place with the great-
"eſt rapidity: a flame of more than four
"inches in length iſſued out of neck of the
"retort while I held it in my hand, which
"carried with it the powder, and very
"deep-coloured vapours of nitrous acid.
"Theſe vapours condenſed into a green li-
"quor, ſcarcely fuming: it conſiſted of
"the nitrous acid, weakened by the water
"which

" which entered into the combination of " that which detonated firſt. I poured new " nitrous acid on the charcoal which re- " mained in the retort, and continued the " proceſs till the whole was intirely de- " ſtroyed by ſucceſſive inflammation.

" I repeated this experiment with cal- " cined lamp-black; the events were the " ſame: the retort was found to contain " only a ſmall portion of aſhes, ſometimes " ſemi-vitrified, and adhering to the bottom " of the retort.

" All charcoals in general attract a con- " ſiderable quantity of humidity. It ap- " peared to me, that charcoal calcined in " the evening, and kept till the next morn- " ing, was no longer proper for theſe ex- " periments, becauſe it became ſenſibly " moiſtened in that ſpace of time. But the " moſt ſingular circumſtance is, that theſe " experiments are capricious, and do not " always ſucceed, though with the ſame " charcoal, the ſame acid, and the ſame " proportions. The following manipula- " tion appeared to me to inſure ſucceſs. If " the acid be poured in the middle of the " powder, it does not take fire: but if, " on the contrary, it be ſuffered to run " down the ſide of the capſule, or crucible, " ſo as to occupy the lower place, the de- " tonation is made from that point; the " powder riſes and takes fire, by the nitrous

" acid,

" acid. When nitrous acid is wanting, the " detonation ceaſes of itſelf, and the ſur- " rounding charcoal remains black."

The action of the other acids on charcoal is not known.

This ſubſtance, aſſiſted by heat, decompoſes all the vitriolic ſalts, and forms livers of ſulphur.

It cauſes nitre to detonate, which burns it, by means of the pure air afforded from the ſalt by the action of the fire. A preparation is made for chemical and pharmaceutical purpoſes, called nitre, fixed by charcoal. Two parts of nitre, and one of powdered charcoal, are mixed, and thrown into a red-hot crucible on the fire. A ſtrong detonation enſues, after which a white maſs remains, conſiſting of the fixed alkali of the nitre and of the charcoal. By lixiviating this mixture, the water diſſolves the fixed alkali, and leaves a ſubſtance ſuppoſed to be an earth.

Liver of ſulphur diſſolves charcoal very readily, both by the dry and moiſt way, and even combines with it more readily than any other ſubſtance. This diſcovery is due to Rouelle.

Metals do not unite with charcoal, but their calces recover the metallic ſtate when heated with this ſubſtance. We have ſeen, at the article of metals, that this phenomenon may readily be accounted for, from the affinity of the oxyginous principle with the carbonaceous principle.

The

The action of vegetable ſubſtances on charcoal has not been much examined. It is only known, that a mixture of this ſubſtance with fat oils renders them inflammable by the nitrous acid; a circumſtance which confirms the theory of Rouelle reſpecting the inflammation of oils by this acid.

All the facts here related, concerning the known properties of charcoal, tend to prove, that this body is compoſed of combuſtible matter, ſalts, and earths.

The peculiar combuſtible matter which conſtitutes more than three-fourths of charcoal, or the carbonaceous principle properly ſo called, is as yet ſcarcely at all known. It appears, however, to have the ſtrongeſt affinity with the oxyginous principle, which it takes from almoſt every other body, and that in many particulars it reſembles plumbago.

The various uſes of charcoal in the arts, and in chemiſtry, are well known.

CHAP. XIX.

Concerning the Fixed Salts and Earths of Vegetables.

WHEN a vegetable coal has been burned, a grey, blackiſh, or white matter remains, according to the nature of the charcoal. This ſubſtance, called aſhes, is very compounded; when well made, it contains only ſaline and earthy ſubſtances, mixed with iron, and a ſmall quantity of manganeſe. When the charcoal has been burned with difficulty, the aſhes ſtill retain a ſmall portion of inflammable matter. M. Lavoiſier, on examining the wood aſhes uſed by the ſaltpetre-makers, found them to contain extractive and reſino-extractive matters. The ſaline ſubſtances obtained, by lixiviation, from aſhes, have been called the fixed ſalts of plants. The incineration of vegetables is uſed for obtaining three kinds of ſalts, which we ſhall here deſcribe.

1. Pot-aſh, from which the vegetable fixed alkali is obtained, is prepared in the north, by burning wood, with which thoſe countries abound. This ſalt is very impure; it often contains combuſtible matters, which diminiſh its whiteneſs, and frequently neutral

tral ſalts, ſuch as the vitriols of pot-aſh, of ſoda, and of lime, the muriates of pot-aſh and of ſoda, a ſmall quantity of cretaceous ſoda, with iron and earthy ſubſtances. To purify this ſalt, it is diſſolved in the ſmalleſt poſſible quantity of cold water. The fluid becomes charged with the alkali, and ſome of the neutral ſalts; and the earth, the charcoal, the iron, and the ſelenite, often contained in pot-aſh, are ſeparated by the filter. This ſolution is then evaporated to a pellicle, and the ſeveral ſalts it contains are ſuffered to cryſtallize by cooling. After ſeveral filtrations, evaporations, and cryſtallizations, when the lixivium no longer affords any neutral ſalt, it is evaporated to dryneſs, and calcined. The ſalt is then cretaceous vegetable alkali, mixed with the ſame alkali in a cauſtic ſtate: it ſeems, however, always to contain ſome neutral ſalts, and a ſmall quantity of earthy ſubſtance, which is depoſited by ſtanding, and may be ſeparated by the filter. After which, it may be uſed in the niceſt chemical experiments.

2. Soda, from which the mineral alkali is obtained, is the reſidue of the combuſtion of plants that grow on the ſea coaſts. It is prepared at Alicant in Spain, in Languedoc, at Cherbourg, &c. by burning various ſpecies of plants. At Alicant, they uſe the kalis; and at Cherbourg, the algas, and fucus, commonly known by the name of

 varech,

varech. The firſt plant contains a much greater quantity of mineral alkali than the ſecond, which affords ſcarcely any. Theſe different plants are burned in a trench. At Cherbourg, when the combuſtion is advanced, and the aſhes are very hot, they are ſtrongly agitated, and kneaded together with large poles. By this motion, the ſubſtance, which is ſufficiently hot to undergo a kind of ſemi-vitrification, takes the form of hard and ſolid lumps, known in commerce by the name of ſalicore, ſalicote, lamarie, and alun catin. The names, by which it is more particularly diſtinguiſhed, denote either the plant from which it was obtained, or the country where it was made. The ſoda of Alicant, likewiſe called barilla, is the beſt for chemical purpoſes, and thoſe arts which require much mineral alkali. The ſoda of Cherbourg, or of varech, contains leſs alkali, and ought not to be uſed in chemical experiments; but it is advantageouſly uſed in the manufacture of glaſs, becauſe the vitreous frit it affords is found to be very ſerviceable in that manufacture.

The ſoda of commerce, chemically conſidered, is a compound of cauſtic ſoda, cretaceous ſoda, cretaceous vegetable alkali in a ſmall quantity, vitriols of pot-aſh and of ſoda, marine ſalt, charcoal, iron in the ſtate of Pruſſian blue, according to the obſervation of Henckel, and earth, partly diſengaged, and

partly

partly combined with fixed alkali, as in that of Cherbourg. To ſeparate theſe ſubſtances, and obtain pure cretaceous ſoda, it is diſſolved in cold diſtilled water, and filtered, to ſeparate the earth, iron, and coaly matter; after which it is evaporated, as we have obſerved concerning pot-aſh. This alkali is purified more eaſily than that of pot-aſh, becauſe, as it cryſtallizes more readily, it can be better ſeparated from the portion of cauſtic ſoda; yet it contains ſome of the neutral ſalts, and Pruſſian blue, when firſt cryſtallized, which muſt be ſeparated by repeated ſolutions and cryſtallizations.

3. Fixed ſalts are prepared in pharmacy, which have been greatly recommended by Tachenius, and are ſtill diſtinguiſhed by his name. The proceſs of this chemiſt conſiſts in placing the plant, whoſe ſalt is propoſed to be obtained, in an iron pot. This veſſel is heated till its bottom is red hot; the plant, which is continually ſtirred, emits much ſmoke, and takes fire, at which time the pot is covered, ſo that the ſmoke may be diſſipated, and the flame extinguiſhed. By this means, the plant is gradually conſumed. When reduced to a kind of blackiſh aſhes, it is lixiviated with boiling water, which affords a yellowiſh, or brown ſalt, by evaporation to dryneſs. This ſalt is often alkaline, but is very impure; it is coloured by much extractive matter, which is mixed with

all the neutral ſalts the plant contained. As it is a ſaponaceous compound, good effects often follow its uſe; but it cannot be ſuppoſed to poſſeſs the ſame virtues as the plant from which it was extracted, becauſe its principles have neceſſarily been altered by the combuſtion. It would be of conſiderable uſe to examine, analytically, the different fixed ſalts of plants, prepared after the manner of Tachenius, in order to diſcover the ſaline and extractive matters they contain, and to determine their virtues, and the doſe in which each ought to be adminiſtered.

4. When all the ſaline matter is waſhed off from the aſhes of vegetables, the remainder is a pulverulent ſubſtance, more or leſs white, or coloured, inſipid, inſoluble in water, and hitherto conſidered as an earthy ſubſtance.

Iron may be extracted from this reſiduum by the magnet. This metal, as well as the mangaueſe which vegetable aſhes have lately been found to contain, exiſted, ready formed, in the vegetable. Many philoſophers have ſuppoſed, that the colours of plants are produced by iron. Mr. Baumé, who, in his memoir concerning clays, has mentioned the earthy reſidue of vegetables, affirms, that it forms alum with the vitriolic acid, and likewiſe ſelenite, ſlightly differing from that which is produced by pure calcareous earth. The other acids afford, with this reſidue, ſpathoſe

ſpathoſe ſalts, and a ſmall portion of martial ſalts. Hence Mr. Baumé thinks that the earth of vegetables conſiſts of clay, and an earth reſembling calcareous earth, though it ſenſibly differs from it, according to him, in not forming quick-lime by the action of fire. He thinks, that the clay is formed in theſe organized ſubſtances by the colliſion to which vitrifiable earth is expoſed, and the action of acids with which it combines; that the clay, once formed, paſſes to the ſtate of calcareous earth, by ſucceſſive elaborations in the tubes of vegetables.

We may here obſerve, that the diſcoveries made in Sweden, on the ſaline nature of bones, which appear to be the ſame with reſpect to animals as the fibrous parts are in vegetable ſubſtances, render it probable, that this reſidue is far from being merely an earth. An accurate analyſis, ſuch as has not hitherto been made, may ſhew, that this ſuppoſed earthy ſubſtance is calcareous phoſpate; at leaſt we may ſuſpect this to be the caſe, ſince the experiments of Margraaf and Berthollet, who have obtained phoſphorus from muſtard ſeed, from gluten, and from ſeveral other vegetable ſubſtances.

CHAP. XX.

Concerning Fermentation in general, and the Spirituous Fermentation in particular.

AFTER having conſidered vegetables in the ſtate in which they naturally exiſt, we ſhall proceed to deſcribe the changes they experience in different circumſtances. Theſe alterations, which intirely depend on their nature, are always the conſequence of a phenomenon called fermentation.

Fermentation is a ſpontaneous commotion in a vegetable ſubſtance, by which its properties are totally changed. This commotion is peculiar to the fluids of organic matters; no other ſubſtances, except thoſe which have been elaborated by the principle of vegetable or animal life, being ſuſceptible of it. Chemiſts have not ſufficiently attended to this important truth, whoſe application to the phenomena which take place in organized bodies, cannot but be of the greateſt uſe in medicine.

There are ſeveral circumſtances required in order that fermentation may proceed. Such are,

1. A certain degree of fluidity: dry ſubſtances, in fact, do not ferment at all.

2. A certain degree of heat. Each kind of fermentation requires a due degree of heat, but cold ſtops the progreſs of every ferment.

3. The contact of air. On this account it is, that organized ſubſtances are very well preſerved, and are not altered in a vacuum.

Chemiſts, after Boerhaave, have diſtinguiſhed three kinds of fermentation: the ſpirituous, which affords ardent ſpirit; the acetous, which affords vinegar, or acid; and the putrid fermentation, or putrefaction, which produces the volatile alkali. It muſt be obſerved, that there are many fermentatory proceſſes which do not ſeem to belong to theſe three kinds; ſuch, perhaps, are the fermentations of bread, of mucilages, that which developes the colouring parts, &c. It has been thought, that the fermentations always follow each other in the order we have mentioned; but there are bodies which become acid, without having previouſly undergone the ſpirituous fermentation; and there are others which putrify without paſſing through the two firſt ſtages. We may likewiſe obſerve, that the inteſtine motion of maturation appears to conſtitute a kind of fermentation, by which ſaccharine matter is produced or diſengaged.

The ſpirituous fermentation, or that which produces

produces ardent ſpirit, may be conſidered with reſpect to, 1. The conditions neceſſary to its production; 2. The phenomena which accompany it; 3. The ſeveral ſubſtances ſuſceptible of this fermentation; 4. Its cauſe; and, 5. Its products.

Experience has ſhewn, that all vegetable matters are not capable of paſſing to the ſpirituous fermentation, but that the union of ſeveral peculiar circumſtances is neceſſary for this purpoſe.

Theſe conditions are, 1. A ſaccharine mucilage. This ſubſtance only is capable of paſſing to the ſpirituous fermentation.

2. A degree of fluidity, ſlightly viſcid. If the vegetable fluid be either too thick, or too thin, it will not ferment.

3. A degree of heat, from ten to fifteen degrees of Reaumur's thermometer, or between fifty-five and ſixty-five of Fahrenheit.

4. A large maſs, in which a rapid commotion may be excited.

When theſe four conditions are united, the ſpirituous fermentation takes place, and is known by the following characteriſtic phenomena.

1. An inteſtine motion is excited in the liquor, which increaſes till the fermentation is well eſtabliſhed.

2. The bulk of the mixture is quickly augmented, and this augmentation follows the progreſs of the inteſtine motion.

3. The

3. The tranſparency of the fluid is diminiſhed by opake filaments, which are agitated, and carried to every part of the fluid.

4. A degree of heat is produced, equal to eighteen degrees, (ſeventy-two and a half Fahrenheit) according to the Abbé Rozier.

5. The ſolid parts, mixed with the liquor, riſe and float, in conſequence of the diſengagement of elaſtic fluid.

6. A large quantity of cretaceous acid gas is diſengaged. This gas forms a ſtratum in the upper part of the fermenting vats, which may be eaſily diſtinguiſhed from air. In this ſtratum it was, that Dr. Prieſtley and Duc de Chaulnes made their valuable experiments. Candles, plunged in this ſtratum, are extinguiſhed, and animals die therein; lime-water is precipitated, and cauſtic alkalis cryſtallize perfectly. This acid, contained in the fermenting vats of brew-houſes, frequently produces the moſt fatal effects on the workmen.

7. The diſengagement of this gas is accompanied with the formation of a great number of bubbles in the viſcid liquor, through which the cretaceous acid muſt paſs.

All theſe phenomena gradually ceaſe, in proportion as the liquor loſes its ſweet and mild taſte, and becomes briſk, penetrating, and capable of producing intoxication.

Neceſſity has induced mankind to prepare fermented

fermented liquids with a great number of different vegetable ſubſtances; but experience has ſhewn, that ſaccharine matters alone are capable of forming this kind of fluid. The following being moſt commonly uſed, require to be enumerated.

1. The juice of grapes produces wine, properly ſo called: it is the beſt of all fermented liquors. The art of cultivating vines, which is of great importance, requires an attention to the following objects. 1. The nature of the ſoil. It is known, that a dry ſoil is in general well adapted to this plant, and that a ſtrong ſoil does not agree with it. 2. The cultivation of this vegetable. It is pruned; its branches are bent, to impede the courſe of the ſap; care is taken that it be expoſed to the heat of the ſun, and more eſpecially to the heat reflected from the earth, &c. It is not manured, &c. 3. The hiſtory of its vegetation, its expoſition, its flowering, the formation and ripening of the grape. 4. The accidents to which it is expoſed, ſuch as froſt, heavy rain, moiſture, &c. 5. The time of vintage, which ſhould be dry and hot. Theſe preliminary circumſtances being known, the art of making wine is to be conſidered, which conſiſts in putting the ſtalked grapes into a veſſel, expoſed to a heat of fifteen or ſixteen degrees, to break, agitate, and turn them over. When the fermentation is excited, and all its phenomena

phenomena take place, the juice of grapes, or muſt, ſhould be neither too fluid, nor too thick; in the firſt caſe, it requires to be thickened by boiling; in the latter, it is diluted with water. When the wine is made, it is drawn off into caſks, which are left open, where it experiences a ſecond inſenſible fermentation, by which its principles are more intimately combined; a fine lye, and a ſalt, known by the name of tartar, being precipitated. To preſerve the wine, rags, dipped in ſulphur, are burned in the caſk which contains it.

The knowledge of the different kinds of wine is an object of conſiderable importance. France produces a great number of excellent wines. Thoſe of Burgundy are preferable to any other for conſtant uſe, becauſe their principles are perfectly combined, and no one predominates over the other. The wines of the province of Orleans reſemble thoſe of Burgundy, when they have been matured by keeping, which combines the exceſs of ardent ſpirit they contain with their other principles. The red wines of Champaigne are excellent, and of a delicate flavour. The white wine of this province, which does not ſparkle, is to be preferred to the ſparkling wine, whoſe penetrating and ſubacid taſte, as well as its property of ſparkling, depend on the cretaceous acid contained in it, when bottled before the fermentation

mentation was finiſhed. The wines of Languedoc and Guienne are of a deep colour, and are excellent bracers and ſtomachics, eſpecially when of a good old age. The wines of Anjou are white, very ſpirituous, and intoxicate quickly.

As to foreign wines, thoſe of Germany, known by the name of Rheniſh and Moſelle, are white, and very ſpirituous; their taſte is keen and penetrating, and they quickly produce intoxication. Some wines of Italy, ſuch as thoſe of Orvieto, Vicenza, the Lachryma Chriſti, &c. are well fermented, and reſemble the good wines of France. Thoſe of Spain and of Greece are in general ſweet, crude, imperfectly fermented, and very unwholſome. We muſt, however, except thoſe of Rota and Alicant, which are with juſtice eſteemed to be ſtomachic and cordial.

2. Apples and pears afford cyder and perry. This ſpecies of wine is very good, and affords good brandy, as M. d'Arcet has ſhewn.

3. Cherries afford a tolerable good wine, from which a kind of brandy is diſtilled, called Kirchenwaſſer by the Germans.

4. Apricots, peaches, and plumbs, afford a wine of inferior quality.

5. Sugar, diſſolved in water, ferments readily: from this kind of wine, a ſpirit, called rum, taffia, guildive, &c. is made.

6. The

6. The ſeeds of gramineous plants, and eſpecially barley, afford a ſpecies of wine, called beer. The art of brewing conſiſts in the following proceſſes. Barley is ſteeped in water for thirty or forty hours, after which it is laid in a heap, to ſprout or germinate; it is then dried in a kiln, and the buds ſeparated by ſifting; after which it is coarſely ground, and is diſtinguiſhed by the name of malt. A certain quantity of malt is put into a veſſel, called the maſh-tun, on which water, nearly boiling-hot, is poured, which diſſolves the mucilage. This being drawn off, a ſecond quantity of heated water is poured on the malt, and in like manner drawn off. This fluid, called wort, is boiled up with hops, and is put, together with yeaſt, into a veſſel, called the cooler. When the fermentation begins to ſubſide, the beer is ſtirred up, and drawn off into caſks; the ſecond fermentation throws up a ſcum, called yeaſt, which ſerves to excite fermentation in future brewings. The germination developes a ſaccharine matter in the barley, to which it owes its property of forming wine: the ſame proceſs ſucceeds with moſt other gramineous ſeeds.

The whole of theſe facts prove, that the ſaccharine matter is the only principle of vegetables capable of paſſing to the ſpirituous fermentation, and that water is neceſſary for the production of this inteſtine motion. M.

Lavoiſier

Lavoisier thinks, that this fluid is decomposed in the operation: the oxyginous principle seizes the carbonaceous matter of the sugar, and forms cretaceous or carbonaceous acid, which is disengaged during this fermentation; while the base of the inflammable gas unites with the oil of the saccharine substance, and forms a very light combustible subtle body, containing much less carbonaceous matter than the sugar, and much more inflammable: this is ardent spirit.

The product of all these fermenting substances, is a liquor more or less coloured, of an aromatic smell, a penetrating and hot taste, which, in small doses, assists the action of weak fibres, but produces intoxication when taken too largely. It is universally known by the name of wine.

The wine of grapes, for example, is composed of a large quantity of water, ardent spirit, an essential salt called tartar, and an extracto-resinous matter, which produces the colour in red wines.

Before we proceed to describe the methods of separating these substances, it will be proper to describe the uses and properties of the fluid itself. Wine dissolves many substances, by virtue of the water, the ardent spirit, and the essential acid salt, of which it is formed. It unites with extracts, resins, certain metals, &c. On these properties depend

depend the preparations of medicinal wines, ſuch as, 1. Emetic wine, prepared by macerating four ounces of crocus metallorum in two pounds of good white wine; the liquid is filtered, or is uſed without filtration, in paralytic or apoplectic caſes. 2. Chalybeat wine, made by digeſting one ounce of ſteel filings with two pounds of white wine: it is an excellent tonic and aperitive medicine. 3. The wines of vegetables, prepared (a) either with red wine, in which aſtringent or aromatic plants are macerated; (b) or with white wine, which is uſually employed with antiſcorbutic plants; (c) or with Spaniſh wine: the wine of Squills, and alſo the liquid laudanum of Sydenham, are prepared with this wine. The latter is made by digeſting two ounces of ſliced opium, one ounce of ſaffron, a drachm of powdered cinnamon and cloves, in a pound of Spaniſh wine. This medicine is a very good ſedative, taken in the doſe of a few drops, eſpecially in caſes in which it is feared that opium may weaken the patient, or ſtop ſome uſeful evacuation.

The action of fire is commonly uſed to decompoſe wine, and ſeparate it into its ſeveral principles. The diſtillation is performed in an alembic of tinned copper, to which a receiver is adapted: as ſoon as the wine boils, a colourleſs fluid, ſlightly opake, and milky, of a hot and penetrating taſte, and a

 ſtrong

ſtrong agreeable ſmell, comes over. This fluid is received, till the vapours no longer take fire by a candle. It is called brandy, and conſiſts of water, ardent ſpirit, and a ſmall portion of oil, which renders it milky at firſt, and after a certain time colours it yellow. The colour of old brandy, in commerce, does not, however, ariſe from the oil alone, which comes over in the diſtillation, but likewiſe from the extractive matter it takes from the caſk in which it is contained. Brandy is the fluid from which ardent ſpirit is extracted, as we ſhall hereafter ſee. The reſidual liquor, after it has afforded ſpirit of wine, is of an acid auſtere taſte, turbid, and depoſits a large quantity of ſaline cryſtals, which appear to be tartar. The wine is therefore intirely decompoſed, and cannot be reſtored to its former properties by combining the ſpirituous product with the reſidue. Hence the analyſis appears to be complicated. If the reſidue of wine which has afforded brandy be evaporated, it takes the form and conſiſtence of an extract. The colouring part may be ſeparated by the addition of ſpirit of wine, which does not act on the tartar. Water does not precipitate this tincture. By evaporation of the tincture to dryneſs, a reſidue is obtained, which quickly takes fire, and is ſoluble in water; it is a true reſino-extractive ſubſtance, which the ardent ſpirit, formed by

fermen-

fermentation, has extracted from the ſkins of the grapes. From this analyſis it appears, that wine conſiſts of water, ardent ſpirit, tartar, and colouring matter; we have already explained the nature and properties of two of theſe ſubſtances, namely, water, and the colouring extract; ardent ſpirit and tartar remain, therefore, to be treated of.

Before we proceed to ſpeak of theſe, we ſhall take notice of a ſubſtance that precipitates from wine during its fermentation, and is called lees. It conſiſts of the ſeeds and ſkins of grapes, impure tartar, and vitriolated tartar. By diſtillation with a naked fire, it affords brandy: treated in a retort, it affords acid phlegm, oil, volatile alkali, and its coal contains cretaceous vegetable alkali and vitriolated tartar. The incineration of the lees of wine, in the open air, affords a cauſtic fixed vegetable alkali, mixed with vitriolated tartar, and known in commerce by the name of cendres gravelées. The account we ſhall proceed to give of ſpirit of wine, and of tartar, will complete what remains to be ſaid concerning the lees of wine.

CHAP. XXI.

Of Ardent Spirit, or the Product of the Spirituous Fermentation.

WE have feen that brandy, obtained by diftilling wine with a naked fire, is a compound of ardent fpirit, water, and a fmall portion of oil. Diftillation is ufed to feparate thefe fubftances, and to obtain ardent fpirit in a ftate of purity. There are feveral methods of diftilling fpirits of wine. M. Baumé advifes to diftill brandy a confiderable number of times, by a water-bath, to obtain all its fpirit. He recommends the feparation of the firft fourth part of the product of the firft diftillation, and likewife of the firft half of the product of the following diftillations; to mix all thefe together, and to rectify by a gentle heat. The firft half of the fluid, which paffes in this rectification, is the pureft ardent fpirit, called alkohol; the remainder is lefs ftrong, but very good for ordinary purpofes. Rouelle directs, that half the brandy made ufe of, be drawn off by diftillation on the water-bath; this firft product is common fpirit of wine, which, being rectified twice, and reduced to about two-

two-thirds, becomes a ſtronger ſpirit. This is to be again diſtilled with water, according to the proceſs of Kunckel, which ſeparates the oil; the diſtilled ſpirit, being again rectified, may be depended on as perfectly pure. The reſidue of brandy, after diſtillation, is water, containing colouring matter, on the top of which a peculiar oil floats.

Hence it may be obſerved, that the purity and ſtrength of ardent ſpirit muſt differ according to the proceſſes uſed in obtaining it. A method of diſcovering its purity has long been ſought after. It was formerly ſuppoſed, that ſpirit of wine, which readily catches fire, and leaves no reſidue, is very pure; but it is at preſent well known, that the heat excited by its combuſtion is ſufficiently ſtrong to diſſipate all the phlegm it might contain. Another proof has been propoſed, by means of gunpowder: when ſpirit of wine, ſet on fire in a ſpoon upon gunpowder, does not inflame it, it is conſidered as bad; if, on the contrary, it ſets it on fire, it is judged to be excellent. But this proof is very fallacious; for when a large quantity of the beſt ſpirit of wine is burned on a ſmall quantity of gunpowder, the water it affords during its combuſtion moiſtens the powder, and prevents its taking fire; whereas it may be inflamed by burning a very ſmall quantity of phlegmatic ſpirit of wine on its ſurface. This method is

therefore no more to be depended on than the former. Boerhaave has deſcribed a very good proceſs for aſcertaining the purity of this fluid: it conſiſts in throwing the very dry powder of fixed ſalt of tartar into ſpirit of wine; this unites with the ſuperfluous water of the ſpirit, and forms a more ponderous and coloured fluid than the ardent ſpirit, with which it does not mix, but falls to the bottom. Laſtly, M. Baumé, on the conſideration that ſpirit of wine is lighter the purer it is, has contrived an areometer, by which the degree of purity of this fluid may be accurately aſcertained. When the inſtrument is plunged in ſpirit of wine, it ſinks deeper, in proportion as the fluid is purer. By experiments carefully made, he has determined, that the pureſt and moſt highly rectified ſpirit of wine gives thirty-eight degrees of his areometer. The method of conſtructing this inſtrument, as well as the reſults afforded by different quantities of ſpirit of wine, may be ſeen in his elements of pharmacy, and may be applied to determine the ſtrength of ſpirit of wine by the hydrometer.*

Pure

* Notwithſtanding the labours of many ingenious chemiſts, and particularly thoſe of Mr. Bories, related in his Memoir, which obtained the prize propoſed by the ſtates of Languedoc, in 1772, and publiſhed at Montpelier in the year 1774, much remains to be done before the ſtrength

Pure ardent ſpirit, obtained by the proceſs we have deſcribed, is tranſparent, exceedingly fluid, and ſo light, that it weighs four hundred and eighty-grains, in a bottle which contains five hundred and ſeventy-ſix grains of diſtilled water. Its ſmell is penetrating, and agreeable; its taſte is hot, and ſtrong. It is extremely volatile, riſing and paſſing over in cloſe veſſels, by a very gentle heat, and is by this means

 ſeparated

ſtrength of ſpirits can be determined, with ſufficient accuracy even for commercial purpoſes. If ardent ſpirit, which is ſo highly dephlegmated as not to liquefy hot pulverized alkali, be conſidered as pure ſpirit, or the ſtandard extreme, diſtilled water forming the other extreme, it will then be neceſſary to aſcertain, by experiment, 1. The ſpecific gravity of a certain number of mixtures of water and this ſpirit, taken ſo near each other, as that the intermediate ſpecific gravities may not ſenſibly differ from thoſe deduced mathematically in the uſual manner. 2. The expanſions, or variations of ſpecific gravity of theſe mixtures, at the different temperatures of the atmoſphere. 3. The change of ſpecific gravity, produced by the ſolution of ſaccharine or oleaginous ſubſtances in theſe ſpirits. 4. Eaſy methods muſt be deviſed to ſhew the preſence and quantity of the laſt mentioned ſubſtances; and alſo, 5. To determine the ſpecific gravity of the fluid.

Theſe requiſites demand a great number of accurate experiments to be made. Rectified ardent ſpirit, repeatedly affuſed on dry alkali, till it would no longer diſſolve or liquefy it, was found, by Mr. Bories, by many experiments, to have the following ſpecific gravity.

Reaumur's Therm. ✠ $10^\circ = 820\frac{2900}{5055}$
✠ $15^\circ = 817\frac{65}{5055}$
✠ $20^\circ = 813\frac{2285}{5055}$

The

ſeparated from the ſmall quantity of water it might contain. The firſt portions are the moſt volatile, and pure. It was formerly thought, that a large quantity of air was always diſengaged during the diſtillation of ſpirit of wine. This ſuppoſed air is now known to be the ſpirit itſelf, in the form of gas.

When ardent ſpirit is heated with the contact of air, it ſoon takes fire, and exhibits a light flame, white in the middle, and blue at the ſides; it completely burns away, when pure. Many chemiſts have at-

* The ſpecific gravities of mixtures, by meaſure, of the foregoing ſpirit with diſtilled water, were as under.

Temperature + 15° Reaumur.

Spirit	Water	Specific gravity
10	0	$817\frac{65}{5055}$
9	1	$844\frac{3580}{5055}$
8	2	$869\frac{4705}{5055}$
7	3	$893\frac{1895}{5055}$
6	4	$915\frac{925}{5055}$
5	5	$934\frac{3630}{5055}$
4	6	$951\frac{3695}{5055}$
3	7	$965\frac{1925}{5055}$
2	8	$976\frac{1320}{5055}$
1	9	$987\frac{715}{5055}$
0	10	1.000

I find, by diſtilling 20 meaſures of the beſt ſpirit of wine of the ſhops, (Sp. Gr. = 836) in glaſs veſſels, by a lamp, that the firſt meaſure which came over had a ſpecific gravity of 820, at a temperature of 71° of Fahrenheit, or about + $17\frac{1}{2}$ of Reaumur. This, which is the ſtrongeſt ſpirit mere diſtillation can afford, contains about one part in the hundred of water, of which it may be deprived by alkali. Note of the Tranſlator.

tempted

tempted to discover the product afforded by spirit of wine in burning. They found that its flame is accompanied with neither soot nor smoke; and that the volatilized matters when condensed, are pure water, without taste or smell, absolutely in the state of distilled water. Boerhaave, from this phenomenon, supposed, that the flame is produced by the water; and this opinion is confirmed by the knowledge we at present possess, respecting the inflammable air obtained by the decomposition of water, and the water obtained by burning inflammable gas. Mr. Lavoisier discovered, that when spirit of wine is burned in a chimney adapted to receive the vapours, a larger quantity of water is obtained than the whole of the spirit made use of amounts to; whence it follows, that this liquor contains a large quantity of inflammable gas. On the other hand, Mr. Berthollet has remarked, that when a mixture of this spirit and water is burned, the residual fluid precipitates lime-water. This experiment shews, that ardent spirit contains a small quantity of carbonaceous matter, which, by its combustion or combination with the oxyginous principle, forms the cretaceous acid. Chemists have adopted different opinions respecting ardent spirit; Stahl, Boerhaave, and some others, have considered this fluid as a compound of a very attenuated oil, a subtle acid, and

water. Others, at the head of whom may be placed Cartheuſer and Macquer, think that ſpirit of wine is formed by the union of phlogiſton and water. The nature of this fluid is not yet well known. Spirit of wine, expoſed to the air, evaporates at a temperature of 55°, and leaves no reſidue, except a ſmall quantity of water, when it has not been well dephlegmated. This evaporation in the air is more rapid, the hotter the atmoſphere; and produces a degree of cold, which is ſtronger in proportion to its rapidity. Spirit of wine has the form of an elaſtic fluid at 185 degrees of Fahrenheit's thermometer.

Spirit of wine unites with water in all proportions, and is perfectly ſoluble in that fluid. This ſolution is attended with heat, and produces mixtures, whoſe ſtrengths are greater in proportion as the quantity of ardent ſpirit is greater. The affinity of combination between theſe two fluids is ſo ſtrong, that water is capable of ſeparating ſpirit of wine from many bodies with which it may be combined; and on the contrary, ſpirit of wine decompoſes moſt ſaline ſolutions, and precipitates the ſalts. From the conſideration of this laſt property, it is, that Boulduc propoſes the uſe of ſpirit of wine to precipitate the ſalts contained in mineral waters, and to obtain them unaltered.

Spirit of wine has no action on pure earths.

earths. It is not known whether it is altered by ponderous earth and magnefia. Lime appears capable of producing fome change in this fluid, fince it acquires a degree of fmell when diftilled from that earthy fubftance. But this alteration has not been properly inquired into.

Fixed alkalis appear really to decompofe fpirit of wine, as is known by the medical preparation called the acrid tincture of tartar. To prepare this, pot-afh is melted in a crucible, pulverized while hot, and put into a matrafs; highly dephlegmated fpirit of wine is poured on, to three or four fingers depth; the matrafs is clofed with another of a fmaller fize, luted together, and the whole is digefted on a fand bath, till the fpirit has acquired a reddifh colour. A great or lefs quantity of alkali remains at the bottom of the veffel. This acrid tincture of tartar affords, by diftillation, a fpirit of wine of a fweet fmell, fcarcely altered; and a fubftance remains in the retort refembling a faponaceous extract, which diftilled with a naked fire, affords fpirit of wine, volatile alkaline fpirit, and a light empyreumatic oil. In this operation, a fmall quantity of charcoal is formed, which is found to contain the vegetable alkali. The experiment feems to fhew, that fpirit of wine contains an oil which is feized by the fixed alkali, and forms a true foap kept in folution

lution in the portion of ardent ſpirit which is not decompoſed. The lilium of Paracelſus does not differ from the acrid tincture of tartar, excepting that the fixed alkali employed in its preparation appears to be rendered cauſtic by the metallic calces with which it was heated. The martial, jovial, and cupreous reguli of antimony, each in the quantity of four ounces, are fuſed together, then reduced into powder, and detonated with eighteen ounces of tartar, and as many of nitre; the whole being melted, pulverized, and put into a matraſs, highly rectified ſpirit of wine is poured on, to the height of three or four inches above the mixture. By digeſtion on a ſand bath, the ſpirit aſſumes a beautiful red colour, deeper than that of the preceding tincture, but preſenting the ſame phenomena. The former tincture may be made intirely ſimilar to the lilium of Paracelſus, by digeſting ſpirit of wine in the cauſtic fixed alkali, inſtead of uſing ſalt of tartar, which is not deprived of its cretaceous acid, unleſs it has been kept red hot a long time. Mr. Berthollet aſcertained that theſe tinctures are merely ſolutions of cauſtic vegetable alkali in ſpirit of wine, and that they afford an uſeful method of obtaining the alkali very pure, by evaporation of the ſpirit. Spirit of wine has the ſame action on pure ſoda. The acrid tinctures of tartar are excellent bracers, and powerful deobſtruents.

deobſtruents. They are uſed in thoſe caſes where the natural forces of the patient are inſufficient to favour the criſis, as in the malignant fever, the worſt kind of ſmall pox, &c.

The action of the cauſtic volatile alkali on ſpirit of wine has not yet been examined.

All the acids preſent very important phenomena with this ſpirituous fluid. When concentrated oil of vitriol is poured on an equal quantity of rectified ſpirit of wine, a ſtrong heat, with a remarkable hiſſing noiſe, is produced; the two ſubſtances become coloured, and emit a ſweet ſmell, reſembling that of lemons, or the apple called golden rennet. If the retort, in which this mixture is uſually made, be placed on a ſand bath with large receivers adapted, the firſt being plunged in a veſſel of cold water, the products are, 1. A ſpirit of wine of a ſweet ſmell. 2. A fluid called ether, of a very agreeable ſmell, extremely volatile, whoſe preſence is aſcertained by the ebullition of the liquor contained in the retort, and by the large ſtriæ which run down the ſides of the veſſel. The receiver muſt now be kept cool by wet cloths. 3. After the ether, a ſulphureous ſpirit paſſes, whoſe white colour and ſmell indicate the proper time for changing the receiver, in order to have the ether ſeparate. 4. At the ſame time a light yellowiſh

lowiſh oil is volatilized, which is called ſweet oil of wine. The fire muſt be greatly lowered after the ether is paſſed, becauſe the matter contained in the retort is black, thick, and ſwells up conſiderably. 5. When the ſweet oil is all diſtilled, ſulphureous acid next comes over, which becomes thicker and thicker; and towards the end dirty and black oil of vitriol. 6. The operation being continued by a gentle heat, the reſidue becomes perfectly dry, and has the form and conſiſtence of a bitumen. By expoſure to a ſtrong heat, an acid liquor and a dry and yellowiſh ſubſtance reſembling ſulphur, is obtained. M. Baumé, who has made a great number of experiments on vitriolic ether, has very carefully examined this reſidue, and found it to contain martial vitriol, Pruſſian blue, a ſaline ſubſtance, and a peculiar earth, whoſe nature he has not aſcertained. He even affirms, that the yellowiſh ſublimate it affords, is not ſulphur, but that it remains white and pulverulent, without taking fire on the coals. To theſe details we ſhall add, that the reſidue of ether affords new ether, by the addition of one-third of ſpirit of wine dephlegmated by ſalt of tartar, and diſtilling the mixture, as Mr. Cadet has ſhewn. Theſe diſtillations may be repeated ſeveral times, and from a mixture of ſix pounds of oil of vitriol and ſpirit of wine, to which fifteen pounds of the lat-

ter

ter fluid are ſucceſſively added, more than ten pounds of good ether may be obtained.

The operation we have deſcribed, is one of the moſt ſingular in chemiſtry for the phenomena it exhibits; and at the ſame time one of the moſt important, with reſpect to the explanation it affords concerning the compoſition of ſpirit of wine. There are two opinions reſpecting the formation of ether, which it is neceſſary to explain. Macquer, who, as we have obſerved, conſiders ſpirit of wine as a compound of water and phlogiſton, thinks that the oil of vitriol takes the water from this ſubſtance, and cauſes it to approach gradually to the characters of oil. According to this opinion, therefore, ſpirit of wine firſt paſſes over ſcarcely altered; next a fluid, which occupies the middle place between water and oil; and laſtly, a true oil, becauſe the vitriolic acid acts ſo much the ſtronger on the principles of the ſpirit of wine, as the heat is more conſiderable. Bucquet made a ſtrong objection to this theory; namely, that it is difficult to conceive, how the oil of vitriol, charged from the firſt with a certain quantity of water it had taken from the ſpirit of wine, could ſtill, notwithſtanding this dilution, re-act ſo ſtrongly on a portion of the ſame ſpirit, as to put it into the oily ſtate. He therefore propoſed another opinion reſpecting the production

duction of ether. He confidered fpirit of wine as a fluid compofed of oil, acid, and water; and imagined, that when the acid of vitriol is mixed with the fpirit, a kind of bituminous fluid is produced, which affords by heat the fame principles as all bitumens; namely, a light, odorous, very combuftible oil, or a fpecies of naptha, which is the ether, and afterwards a lefs volatile and more coloured oil, which is the fweet oil of wine. We fhall, in fact, perceive by the properties of ether, which we are about to explain, that this fluid has all the characters of a highly attenuated oil, fuch as naptha. This theory does not explain, with fufficient perfpicuity, what happens during the preparation of ether. The oxyginous principle appears to be taken from the vitriolic acid by the fpirit of wine, and to be one of the principles of the ether.

Ether obtained by the procefs we have defcribed, is not in a ftate of purity, but contains fpirit of wine and fulphureous acid. It muft be rectified by diftillation in a retort, on a fand bath, with the addition of fixed alkali. The falt combines with the fulphureous acid, and the ether paffes over in a ftate of great purity, by the gentleft heat. The firft part of this product being received feparate, is the pureft and moft highly rectified ether.

Ether is a fluid much lighter than fpirit

of

of wine, of a ſtrong, ſweet, and very expanſible ſmell, of a hot and penetrating taſte. It is ſo volatile, that it is inſtantly diſſipated by agitation, or pouring out. During its evaporation, it produces a degree of cold ſufficient to freeze water, as M. Baumé has ſhewn in his experiments. It takes the form of gas, which burns with great rapidity. Air, which holds ether in ſolution, may be paſſed through water without loſing its ſmell and inflammability. Ether takes fire very readily when heated in the open air, or brought into contact with an inflamed ſubſtance. The electric ſpark likewiſe ſets it on fire. Its flame is very luminous, and leaves a black coaly mark on ſubſtances expoſed to it. M. Lavoiſier has proved, that cretaceous acid is formed during the combuſtion of this liquor; and Mr. Scheele found that the reſidue of ether burned on a ſmall quantity of water, contains vitriolic acid.

Ether diſſolves in ten parts of water, according to the Count de Lauraguais. The phenomena produced by adding to ether all the ſaline ſubſtances, have not yet been examined; little more being known, than that the action of ſome acids, lime, and fixed alkalis, do not appear capable of changing it. The cauſtic volatile alkali mixes with it in all proportions, and forms a fluid, whoſe odour may be very uſeful in ſpaſmodic diſorders.

Oil of vitriol becomes much heated by mixture with ether, and converts a conſiderable part of it into ſweet oil of wine by diſtillation. The fuming nitrous acid excites a conſiderable effervefcence; the ether appearing to become more conſiſtent, oily, and of a deeper colour in this experiment. Ether has not been combined with the other ſaline ſubſtances, nor even with the inflammable mineral ſubſtances. It is aſcertained, that ether diſſolves eſſential oils and reſins, like ſpirit of wine; and etherial tinctures are accordingly uſed in medicine.

Ether is conſidered as a powerful tonic, and anti-ſpaſmodic remedy. It is uſed in hyſteric diſorders, and ſpaſmodic cholics, and is of excellent ſervice in caſes where digeſtion is ill performed on account of weakneſs of the ſtomach. It muſt be adminiſtered, however, with prudence, becauſe its exceſſive uſe is dangerous. It is likewiſe ſucceſsfully applied externally in head-achs, burns, &c. Hoffman, who made many experiments with the vitriolic acid, and ſpirit of wine, uſed a medicine compoſed of ſweet oil of wine diſſolved in ardent ſpirit, which he called his mineral anodyne liquor. The Faculty of Medicine at Paris have added ether to this liquor, and preſcribe it to be prepared by mixing two ounces of the ſpirit of wine which paſſes in diſtillation before the ether, two ounces of ether,

and

and twelve drops of ſweet oil of wine. This medicine is employed for the ſame purpoſes as ether, but is far from having the ſame efficacy.

The nitrous acid acts very ſtrongly on ſpirit of wine. M. Navier is the firſt who deſcribed an eaſy and cheap method of preparing nitrous ether. He directs twelve ounces of very pure and well rectified ſpirit of wine to be poured into a very ſtrong glaſs bottle, and plunged in cold water, or which is ſtill better, in pounded ice: to this is to be added, in ſeveral portions, the liquor being agitated each time, eight ounces of ſpirit of nitre; after which the bottle muſt be cloſed with a good cork, covered with leather, and well ſecured. This mixture is then to be left in a remote or private place, to prevent accidents that might ariſe from the burſting of the bottle, which ſometimes happens. After ſome hours, bubbles ariſe from the bottom of the veſſel, and are gradually collected at the top, forming a ſtratum of true ether. This diſengagement continues from four to ſix days. As ſoon as the liquor appears to be at reſt, the cork muſt be pierced with an inſtrument, that a certain quantity of air may eſcape, which, without this precaution, would ruſh out on opening the bottle, and carry the ether with it. As ſoon as the air is diſſipated, the bottle is to be uncorked, and the fluid it contains poured into a funnel,

whoſe lower aperture being ſtopped with the finger, the reſidue may be ſeparated from the ether which floats above, and muſt be kept in a ſeparate veſſel.

Mr. Woulfe deſcribes another proceſs for preparing nitrous ether. It conſiſts in uſing very large veſſels, that the diſengaged air may have a conſiderable ſpace to expand itſelf in. A matraſs of white glaſs, containing eight or ten pints, and terminated by a neck of ſeven or eight feet long, is placed on a tripod ſufficiently high to admit of a chafing-diſh being put underneath. To the neck of this matraſs, a tubulated head is adjuſted, with a tube of ſeven or eight feet long adapted to its beak. The lower extremity of the tube is received in a veſſel with two necks, whoſe lower part is drawn out into a tube, which is inſerted in a bottle. To the other neck of this receiver is adapted the apparatus of bottles, which we have frequently mentioned as the invention of Mr. Woulfe. Theſe veſſels being well luted together, one pound of rectified ſpirit of wine, with an equal quantity of fuming ſpirit of nitre are poured into the matraſs, through the perforation in the head; this perforation is then cloſed with a ground ſtopper wrapped round with a piece of leather. As ſoon as the mixture is made, it becomes ſtrongly heated, vapours are diſengaged, which paſs rapidly along the neck of the

the matraſs, and by applying a ſufficient degree of heat to make the mixture boil, nitrous ether paſſes into the receiver. This proceſs, though very ingenious, has its inconveniencies. The adjuſtment of the apparatus is difficult, and the veſſels are very expenſive; beſides which, the method is dangerous; becauſe, notwithſtanding the ſpace afforded to the vapours, they are diſengaged with ſo much rapidity, that the veſſels frequently fly in pieces.

Mr. Bogues, in the year 1773, publiſhed another proceſs for making nitrous ether. He directs one pound of ſpirit of wine to be mixed with one pound of nitrous acid, weakened ſo as to exhibit only twenty-four degrees of Beaumé's hydrometer, in a glaſs retort, containing eight pints; to this a receiver of twelve pints is to be adapted, the air is ſuffered to eſcape by adjuſting the barrels of two quills at the juncture of the lute, and the diſtillation muſt be performed by a very gentle heat. By this means he obtained ſix ounces of nitrous ether, of conſiderable purity. It appears, from the account of the Abbé Rozier, that Mr. Mitouard, as early as the year 1770, uſed a proceſs nearly ſimilar to that of Mr. Bogues. This chemiſt expoſed four ounces of fuming ſpirit of nitre with twelve ounces of ſpirit of wine to diſtillation in a retort, which he placed

lightly on the ſand, and by this method, which appears the moſt ſimple of any, he obtained nitrous ether. Laſtly, Mr. De la Planche, apothecary at Paris, has invented two methods of preparing nitrous ether very conveniently. The firſt conſiſts in putting nitre into a tubulated ſtone-ware retort, to which a large receiver, with an adopter, is fitted; oil of vitriol is firſt poured to the nitre through the tube, and afterwards ſpirit of wine. The vitriolic acid diſengages the ſpirit of nitre, which re-acts on the ſpirit of wine, and forms nitrous ether, almoſt immediately. As it might be ſuſpected that the ether prepared in this way was partly vitriolic, he has ſubſtituted inſtead of this method, another, which is very ingenious. An adopter, and a receiver, which communicates, by a recurved tube, with an empty bottle, are affixed to a tubulated glaſs retort, containing ſix pounds of very dry nitre. The laſt veſſel, namely the bottle, communicates by means of a ſyphon, with another bottle, containing three pounds of the pureſt ſpirit of wine. The whole being well luted, and the retort placed on a bath of aſhes, three pounds of very pure oil of vitriol is poured on the nitre through the tube, which is immediately cloſed with a ground ſtopper. The mixture is then heated to ebullition, and kept in that ſtate till no more vapours paſs over. In this experiment, the

the vitriolic acid disengages the acid of nitre, which passes partly into the receiver, and partly into the second bottle. When the operation is ended, the receiver contains fuming spirit of nitre, the retort vitriolated tartar, and the second bottle an etherial liquor. This last is distilled in a retort with a receiver, in the usual method, no more than two-thirds of the liquid being brought over. The product is again distilled with a fifth part of fuming spirit of nitre, poured in by a little at a time, through a glass funnel with a long neck; two-thirds of this liquid being likewise distilled over. Lastly, the second product is rectified by distillation from salt of tartar; the first four ounces being kept apart, and three-fourths of the remainder suffered to come over. The four ounces are very pure nitrous ether; the three-fourths of the remainder are a nitrous mineral anodyne liquor. The residues of the two rectifications are dulcified spirit of nitre.

Nitrous ether obtained by these processes, is a yellowish fluid, as volatile and evaporable as vitriolic ether, whose smell it resembles, though it is stronger, and not so agreeable; its taste likewise is hotter, and more pungent than that of vitriolic ether. It contains a small portion of superabundant acid. A large quantity of air is continually disengaged from it, which causes the stoppers of

of the bottles containing it to fly out frequently. Its flame is brighter, and the ſmoke it emits when burned, is denſer than that of the vitriolic ether; it leaves a larger coaly reſidue; and laſtly, like the vitriolic ether, it takes gold from its ſolutions, and ſuſpends a certain quantity.

The reſidue of nitrous ether is of a lemon yellow colour, its ſmell is acid and aromatic, and its taſte is penetrating, and reſembles that of diſtilled vinegar. It affords, by diſtillation, according to Baumé, a clear liquor of a milder taſte than that of nitrous ether, being an agreeable acid, which reddens ſyrop of violets, unites with water in all proportions, and effervеſces with cretaceous vegetable alkali. The retort contains a yellow friable matter, of the appearance of amber, which attracts the humidity of the air, becomes of a pitchy conſiſtence, and is ſoluble in water without rendering it mucilaginous. This, which Mr. Baumé calls a gummy ſaponaceous ſubſtance, if the diſtillation be continued, affords a few drops of a very clear acidulous fluid, of an oily conſiſtence, and ſlightly empyreumatic ſmell. A ſpungy, brilliant, taſteleſs, very fixed coal remains. Bucquet affirms, that if the liquor which remains after the formation of nitrous ether be evaporated, it aſſumes the conſiſtence of a mucilage, and at the end of a certain time, affords ſaline cryſtals reſembling

reſembling hairy caterpillars, which have been called cryſtals of Hiærne, from the name of the chemiſt who firſt deſcribed them. It has ſince been diſcovered, that this reſidue is the acid of ſugar, which proves that the combuſtible baſe of that acid is contained in ſpirit of wine.

The muriatic acid does not ſenſibly act on ſpirit of wine; this acid being only dulcified by ſimple mixture with the ſpirit, as are likewiſe the two others when mixed with a large proportion of ſpirit. Mr. Baumé, in his diſſertation on ether, aſſerts, that he obtained a ſmall quantity of marine ether, by cauſing ſpirit of ſalt and ſpirit of wine to meet in the form of vapour. Ludolf and Pott uſed butter of antimony with the ſame intention. Baron Born directs the ſolution of flowers of zink in the marine acid, and diſtillation of this ſalt concentrated by evaporation in cloſe veſſels, with ſpirit of wine. This proceſs affords marine ether, with conſiderable facility. But no one has purſued this inquiry with ſo much diligence and ſucceſs as the Marquis de Courtanvaux. According to the proceſs of this chemiſt, a pint of ſpirit of wine is to be mixed in a retort with two pounds and a half of the ſmoking liquor of Libavius; a ſtrong heat is excited, and a white ſuffocating vapour ariſes, which diſappears when the mixture is agitated; an agreeable ſmell is then perceived, and the mixture

aſſumes

aſſumes a lemon colour. The retort is to be placed on a hot ſand bath, two receivers being luted on, the outer of which is plunged in cold water. A dephlegmated ſpirit of wine firſt paſſes over, and afterwards the ether riſes, which may be perceived by its ſmell, and the ſtriæ it forms in the neck of the retort. As ſoon as the ſmell changes, and becomes ſtrong and ſuffocating, the receiver muſt be changed; a clear acid liquor then comes over, on the top of which float a few drops of ſweet oil. This is ſucceeded by a yellow butyraceous matter, or true butter of tin; and laſtly, a brown ponderous liquor, which emits abundance of white vapours. A grey pulverulent matter, or calx of tin, remains in the retort. The etherial product being poured on oil of tartar in a retort, a ſtrong effervefcence takes place, and an abundant precipitate is thrown down, which is produced by the tin that came over in the diſtillation. A ſmall quantity of water is then added, and a ſecond diſtillation is performed by a gentle heat; the firſt half of the product being etherial. All the fluids, which paſs after the muriatic ether, are loaded with tin; they attract the humidity of the air, and unite with water, without affording any precipitate. It was formerly very difficult to determine the cauſe of the ſtrong action of the muriatic acid contained in the fuming liquor on ſpirit of wine, ſince the pure acid does not at all

act

aċt on that inflammable fluid. But, ſince the diſcovery of Mr. Scheele, it appears to be owing to the dephlogiſticated or aerated ſtate of the acid; and that its property of converting ſpirit of wine into ether muſt be attributed to the exceſs of the baſe of air it contains. This theory was firſt explained by me in the year 1781, and is now confirmed by the experiments of Meſſrs. Berthollet and Pelletier.

M. de la Planche, the apothecary, has propoſed to make muriatic ether, by pouring oil of vitriol and ſpirit of wine on decrepitated marine ſalt, in a tubulated retort. The muriatic acid gas diſengaged by the vitriolic acid, meets the vapour of ſpirit of wine in the receiver, and combines with it. An etherial acid is produced, which may be purified by a ſecond diſtillation from fixed alkali. In this proceſs, the muriatic acid appears to take a portion of the oxyginous principle from the vitriolic acid.

Muriatic ether is very tranſparent; its ſmell is nearly the ſame as that of vitriolic ether; it likewiſe burns in the ſame manner, and affords a ſimilar ſmoke. But it differs in two properties; the one, that when burning it exhales an odour as penetrating as the ſulphureous acid; the other, that its taſte is ſtyptic like that of alum. Theſe two phenomena ſhew, that this ether is different, and perhaps leſs perfect than the

two

two foregoing; and there is no doubt but when its other properties ſhall be examined, other differences, equally remarkable, will be obſerved.

After having thus treated of the action of three mineral acids on ſpirit of wine, we ſhall reſume the hiſtory of this fluid. The action of other acids on ardent ſpirit has been little examined. It is only known, that it readily unites with the acid of borax, or ſedative ſalt, which communicates a green colour to its flame; and that it abſorbs more than its bulk of cretaceous acid. As to the neutral ſalts, Macquer has determined, that vitriolic ſalts are not diſſolved in this menſtruum but with difficulty; that the nitrous and the muriatic ſalts unite with it much more readily; and that in general it diſſolves ſaline ſubſtances with more facility in proportion as their acid is leſs adherent. Spirit of wine boiled on the vitriols of pot-aſh and of ſoda, diſſolved no part. Cretaceous vegetable alkali and ſoda do not unite with it, but moſt ammoniacal ſalts do. Deliqueſcent earthy ſalts, ſuch as the combinations of lime and magneſia, either with the nitrous or marine acid, are perfectly diſſolved. Some metallic ſalts are likewiſe very ſoluble, ſuch as martial vitriol in the ſtate of mother water, cupreous nitre, the muriates of iron and of copper, and corroſive ſublimate; all the

the cupreous ſalts communicate a beautiful green colour to its flame. Mr. De Morveau has, ſince the time of Macquer, given a very accurate table of the degrees of ſolubility of ſalts by ardent ſpirit. This table is inſerted in the Journal de Phyſique.

Spirit of wine does not diſſolve ſulphur either when in maſſes, or in powder; but theſe two bodies unite when they meet in the vaporous form, as the Count de Lauraguais has diſcovered. His proceſs conſiſts in putting flowers of ſulphur into a glaſs cucurbit, upon which flowers he places a ſmaller veſſel, filled with ſpirit of wine. A head and receiver being adapted, and the apparatus being heated by a ſand bath, both ſubſtances riſing together, combine and form a fluid, which paſſes into the receiver rather in a turbid ſtate, and emits a fetid ſmell. It contains about one grain of ſulphur in the drachm of ſpirit of wine. I have diſcovered that the ſame combination may be obtained by diſtilling hepatic waters, ſuch as thoſe of Enghien, with ſpirit of wine.

Ardent ſpirit has no action either on metallic ſubſtances, or their calces. It partly diſſolves certain bitumens, ſuch as amber and ambergris. It does not act on thoſe which are black and coaly. It has been obſerved, that ſpirit of wine diſtilled from fixed alkalis, acts more ſtrongly on theſe bitumens, and that a mixture of alkali with theſe

thefe renders them more foluble; doubtlefs, by converting them into a kind of foap.

There are few vegetable matters on which fpirit of wine does not act more or lefs. Extracts lofe their colouring part, and when they are of the refino-extractive, or extracto-refinous kind, great part is diffolved. Saccharine and faponaceous juices alfo unite with this fluid. Margraaf, by means of ardent fpirit, obtained a faccharine effential falt from beet root, fkirwort, parfnips, &c. But the matters with which it combines the moft readily, are the effential oils, fpiritus rector, camphor, balfams, and refins. The name of fpirituous diftilled waters is given to fpirit of wine impregnated with the fpiritus rector of plants. Thefe fluids are obtained by diftillation from odoriferous plants with fpirit of wine. The fpirit feizes the principle of fmell, and rifes with it, carrying up at the fame time a certain quantity of effential oil, which caufes it to become white by the addition of diftilled water; but this principle may be feparated by rectification on a water-bath, with a very gentle heat, care being taken to draw off no more than three-fourths of the fpirit, in order to be certain of having only the fpiritus rector. Thefe fpirituous diftilled waters acquire a more agreeable fmell by keeping; the odorous principle appearing to combine more intimately with the fpirit.

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The ſpiritus rector has ſo ſtrong an affinity with ſpirits of wine, that this fluid takes it from eſſential oils and water. In fact, when ſpirit of wine is diſtilled from eſſential oils, or from water charged with the ſmell of a plant, it takes the odorous principle, and leaves the oil or water without ſmell. It is obſerved, that ſpirit of wine diſſolves the ponderous and thick eſſential oils more perfectly than thoſe which are fluid and light. Water ſeparates this compound by precipitating the oil in the form of white opake globules; but the ſpiritus rector remains united to the ſpirit of wine. Spirit of wine readily diſſolves camphor in the cold, but it diſſolves a larger quantity by the aſſiſtance of heat. This ſolution, when well ſaturated, as for example, two drachms of camphor to one ounce of ſpirit of wine, being diluted with water, added drop by drop, affords a cryſtalline vegetation obſerved by Mr. Romieu. It conſiſts of a perpendicular ſtem, into which fibres are inſerted, forming an angle of 60 degrees with the perpendicular ſtem. This experiment ſeldom ſucceeds, and requires many trials to aſcertain the quantity of water, the degree of cooling, &c.

The names of tinctures, elixirs, balſams, quinteſcences, &c. are given to compounds of oily or reſinous juices in ſpirit of wine, which is ſufficiently charged to have a high

colour,

colour, and to afford an abundant precipitate by water. Like diſtilled water, they are diſtinguiſhed by the denomination of ſimple, when they contain but one ſubſtance in ſolution; or compound, when they contain many. Theſe medicines are, in general, prepared by expoſing the dry vegetable itſelf, whoſe eſſential oil or reſin is required to be extracted, or the pulverized extract of the plant, to the action of ſpirit of wine, which is aſſiſted either by agitation, or the heat of the ſun, or a ſand bath. When the reſins of a number of plants, or vegetable ſubſtances, are required to be diſſolved in the ſame ſpirit, care muſt be taken to digeſt that ſubſtance firſt, which is the moſt difficultly acted on by the ſpirit; and to add the other ſubſtances in the order of their ſolubility. When the menſtruum has exhauſted its action, and is ſaturated, it is to be ſtrained off. A compound tincture is ſometimes extemporaneouſly made, by mixing ſeveral ſimple tinctures. Thus the elixir proprietatis is made, by mixing the tinctures of myrrh, ſaffron, and aloes. Reſins and balſams may be ſeparated from ſpirit of wine by the affuſion of water, or by diſtillation; but in either caſe, the ſpirit retains the odorous principle.

Water is not capable of decompoſing tinctures formed with the extracto-reſinous, or reſino-extractive ſubſtances, ſuch as the

tincture of rhubarb, ſaffron, opium, gum ammoniac, &c.; becauſe theſe ſubſtances are equally ſoluble in both menſtrua.

Spirit of wine and brandy are of the moſt extenſive uſe: the latter is drank with the intention of recruiting the animal forces; but it is dangerous if exceſſively uſed, becauſe it dries the fibres, and produces tremblings, palſies, obſtructions, dropſies, and other diſorders. Spirit of wine, either pure, or with the addition of camphor, is uſed to ſtop the progreſs of gangrenes.

Spirituous diſtilled waters are adminiſtered in medicine, as tonic, cordial, antiſpaſmodic, ſtomachic, &c. They are given either diluted in water, or ſoftened by the addition of ſyrup.

The drinks called ratafias, or cordials, are made with theſe diſtilled waters and ſugar. When they are well prepared, and taken in ſmall quantities, they may be uſeful; but in general, they can be of ſervice only to few, and may produce bad conſequences to moſt who take them. The exceſſive uſe of this kind of liquors is truly dangerous, for inſtead of ſtrengthening the ſtomach, they in general produce the contrary effect. Thoſe which are the leaſt pernicious, when occaſionally taken with moderation, may be prepared without heat, by infuſing the aromatic ſubſtance in one part of rectified

 ſpirit

ſpirit of wine, with two parts water, and one of fine ſugar.

Tinctures have nearly the ſame virtues as the ſpirituous diſtilled waters, but their action is much ſtronger; for which reaſon they are uſed in ſmall doſes in pills, or with wine, or water. The precipitates they form in this laſt caſe, are ſuſpended for a ſufficient time in the mixture, and the odorous part remains diſſolved in the ſpirit of the tincture.

Laſtly, ſpirit of wine united to copal, oil of aſpic, or of the greater lavender, or to oil of turpentine, forms varniſhes which are called drying; becauſe, when applied on any ſubſtance, the ſpirit of wine evaporates, and leaves a tranſparent reſinous coating. A mixture of eſſential oil prevents theſe varniſhes from drying too quickly, and communicates a degree of unctuoſity, which renders them leſs brittle.

C H A P. XXII.

Concerning Tartar.

TARTAR is an eſſential ſalt, united to a portion of vegetable fixed alkali and oil. It is depoſited on the ſides of caſks during the inſenſible fermentation of wine.

It

It is not produced by the ſpirituous fermentation, as ſome chemiſts have ſuppoſed; for Rouelle the younger diſcovered it ready formed in unfermented wine, or muſt, and in verjuice.

It has the form of irregular plates, diſpoſed in ſtrata, often full of brilliant cryſtals, and of a vinous acid taſte. It is diſtinguiſhed into white tartar, and red tartar, the latter differing from the former only in a greater abundance of colouring matter.

Crude tartar expoſed to heat in cloſe veſſels, affords a reddiſh acid phlegm, an oil at firſt light, and afterwards ponderous, coloured, and empyreumatic; a ſmall quantity of volatile alkali, and much cretaceous acid, which Hales, Boerhaave, and many other chemiſts ſuppoſed to be air. A coal remains, which contains a large quantity of cretaceous vegetable alkali, and is eaſily burned. Vegetable alkali, of conſiderable purity, is obtained by the combuſtion and incineration of tartar.

With this intention, pulverized tartar is wrapped up in papers, which are afterwards dipped in water; theſe are ranged in a furnace, between two ſtrata of charcoal, which being ſet on fire, the tartar burns, and is calcined; when the fire is burnt out, the papers of tartar are found in their original form; theſe are lixiviated with cold diſtilled water, which after filtration is evaporated

to a pellicle, and ſuffered to cool, in order to ſeparate the vitriolated tartar, which cryſtallizes by repoſe. The fluid ſolution being decanted off, is evaporated and cryſtallized a ſecond time; and this proceſs is repeated as long as any cryſtals are afforded: after which it is evaporated to dryneſs, and affords vegetable alkali, partly cauſtic, and partly combined with cretaceous acid.

Tartar is but ſparingly ſoluble in water: one ounce of that fluid, at the temperature of 55 degrees of Fahrenheit, diſſolved no more than four grains. As it contains a large quantity of oleaginous colouring matter, it is purified by ſolution and cryſtallization, at Aniane and Calviſſon, in the neighbourhood of Montpellier. Dr. Fizes has given a full deſcription of this purification, in a memoir printed among thoſe of the Academy in 1725.

The tartar is boiled in water, and filtered while hot; the ſolution becomes turbid on cooling, and depoſits irregular cryſtals, which form a paſte; the paſte is boiled in copper veſſels, together with water, mixed with an argillaceous earth, brought from Merviel, two leagues from Montpellier. A ſcum riſes to the top, which is carefully taken off, and is at length ſucceeded by a ſaline pellicle. The fire is then put out; and the pellicle being broken, falls to the bottom, among the cryſtals which precipitated from the ſolution. The earth, which fouls theſe cryſtals, is

waſhed

washed off with cold water, and they are then sold, under the name of cream of tartar, or crystals of tartar; which differ only in the circumstance, that the cream is formed at the surface, while the crystals are deposited at the bottom of the liquor. The white clay appears to deprive the tartar of its superabundant oily and extractive matter.

Tartar according to M. Desmaretz, is, purified in a somewhat different manner at Venice. The pulverized salt, being dissolved in boiling water, deposits its impurities, from which it is carefully separated, and the liquor affords crystals by cooling. These crystals are re-dissolved in water, gradually heated; and as soon as it boils, beaten whites of eggs, with sifted wood ashes, are thrown in. This mixture of ashes is made fourteen or fifteen times; the scum is taken off, and the liquor left to cool. A pellicle of very white saline crystals is soon formed, which after the water is decanted, are suffered to dry. This method changes the nature of the cream of tartar, by converting a part into tartarized vegetable alkali. We shall proceed to examine the chemical properties of cream of tartar, or tartar purified in the neighbourhood of Montpellier.

Very pure cream of tartar is crystallized, though irregularly; it has an acid taste, less vinous than that of crude tartar. On hot coals, it emits much smoke, of a penetrating empy-

reumatic ſmell, and itſelf becomes black and carbonaceous. If cream of tartar be diſtilled in an earthen retort, with a receiver, connected with an inverted veſſel of water, by means of a tube, and the fire be gradually raiſed, a phlegm, almoſt colourleſs, and ſcarcely acid, firſt comes over; next a ſtronger acid, of a deeper colour; and afterwards an oil, which becomes more and more coloured, conſiſtent, and empyreumatic; and laſt of all, the concrete volatile alkali, and a large quantity of cretaceous acid. A very abundant coal remains in the retort, which, lixiviated without incineration, affords a large quantity of fixed alkali. The diſtilled products may be rectified by a gentle heat. In this rectification, the phlegm paſſes over nearly colourleſs, the oil becomes very white and volatile, the volatile alkali partly combines with the acid, and is not obtained ſeparate and pure, but by diſtilling the laſt portions of phlegm with the addition of fixed alkali. The vegetable fixed alkali, contained in the coal, is not produced in the operation, as many chemiſts have thought, but is all contained originally in the tartar. The re-action of the fixed alkali on the oil produces the volatile alkali; and the quantity of volatile ſalt may be increaſed, by diſtilling the oil obtained from the cream of tartar a ſecond time, with the coal it leaves in the retort.

Cream

Cream of tartar is not altered by expoſure to air.

It diſſolves in twenty-eight parts of boiling water, and cryſtallizes confuſedly by cooling, as we have obſerved. A certain quantity of earth ſeparates from the ſolution of this ſalt, which is doubtleſs that which was uſed in its purification: the ſolution reddens tincture of turnſole, and has an acid taſte.

The action of quartzoſe earth, clay, and ponderous earth, or barytes, on cream of tartar, is not known. The chemiſts of the academy of Dijon have obſerved, that magneſia forms, with cream of tartar, a ſoluble ſalt, decompoſable by fixed alkali, and affording, by evaporation in the open air, ſmall priſmatic cryſtals in radii. This tartar of magneſia boils up, and becomes converted into a light coal, by expoſure to the action of fire. M. Poulletier de la Salle obtained from this combination a gelatinous maſs, perfectly reſembling mucilage.

The action of lime, and of chalk, on cream of tartar, has been well deſcribed by ſeveral chemiſts. When chalk is thrown into a ſolution of cream of tartar, an effervеſcence is produced, occaſioned by the diſengagement of cretaceous acid; and a very abundant precipitate, conſiſting of a combination of the tartareous acid and lime, is formed. The ſupernatant liquor contains a neutral ſalt, which

which exifted, ready formed, in the cream of tartar, and confifts of the acid of tartar, united to vegetable alkali: it is known, as we fhall prefently fee, by the name of foluble tartar. We are indebted to Rouelle the younger for this valuable analyfis of cream of tartar; which proves, 1. That this fubftance is compofed of a fuperabundant oily acid, and a certain quantity of this acid, united to vegetable fixed alkali, in the ftate of a neutral falt. 2. That the combination of the tartareous acid with lime, forms a neutral falt of very difficult folubility. Mr. Prouft has difcovered, that calcareous tartar, diftilled in a retort, leaves a refidue, which takes fire by expofure to air, like pyrophorus. Bergman, in his differtation on the elective affinities, gives a procefs for feparating the the tartareous acid. He directs the precipitate formed by chalk thrown into a folution of cream of tartar, to be wafhed with diftilled water; this tartarized lime being then put into a phial, eight times its weight of vitriolic acid, confifting of one part of oil of vitriol, and eight water, muft be poured thereon. After digefting for twelve hours, and being frequently ftirred with a fpatula of wood, the clear liquor muft be decanted off from the mixture; the depofition at the bottom muft likewife be wafhed with water, till it no longer communicates any tafte; and the water ufed in

wafhing

waſhing is to be added to the former liquid. This is the tartareous acid. It is evident, in this experiment, that the vitriolic acid decompoſes the calcareous tartar, and forms ſelenite, at the ſame time that it diſengages the tartareous acid, which remains diſſolved in the water. The acid thus obtained almoſt always contains a ſmall quantity of vitriolic acid, which may be precipitated by the addition of a ſmall quantity of calcareous tartar, the earth falling down with the vitriolic acid, in the form of ſelenite, while the tartareous acid is diſengaged. Bergman adds, that the ſolution of this acid, evaporated to the conſiſtence of ſyrup, affords cryſtals, in plates or ſcales; that theſe cryſtals become black by heat, and afford, by diſtillation, an acidulous phlegm, with a ſmall quantity of oil; leaving a reſidual coal, which is neither acid nor alkaline. Hence it appears, that the tartareous acid contains oil, like all the other acids of vegetables.

Cream of tartar unites very well with the different alkalis. If it be added to a ſolution of cretaceous vegetable alkali, a ſtrong efferveſcence is immediately produced, by the diſengagement of the cretaceous acid. The cream of tartar muſt be added to ſaturation, and the liquor filtered, after having boiled for half an hour; after which, the evaporation being continued till a pellicle is formed, the ſolution, by ſlowly cooling, affords

affords long quadrangular priſms, terminated by two facets, placed ſlantwiſe. This ſalt is known by the names of vegetable ſalt, ſoluble tartar, tartarized tartar, and ought to be called tartar of pot-aſh. It has a bitter taſte; is converted into a coal by a ſtrong heat; and is decompoſed by diſtillation, affording an acid phlegm, oil, and a large quantity of cretaceous acid. It ſlightly attracts the humidity of the air, and is completely diſſolved in four parts of water, at the heat of 120 degrees. The mineral acids decompoſe it, and precipitate cream of tartar; it is alſo decompoſed by moſt metallic ſolutions.

Cream of tartar, combined with ſoda, forms ſalt of Seignette, ſo called from the name of an apothecary of Rochelle, who firſt compoſed it. It is prepared, by diſſolving twenty ounces of cream of tartar in four pounds of water, and gradually adding very pure cryſtallized vegetable alkali to ſaturation, which point is known by an effervefcence not being excited by the addition of more alkali. In this combination the cream of tartar is rendered more ſoluble. The fluid being evaporated, till it has nearly the conſiſtence of ſyrup, affords, by cooling, very beautiful regular cryſtals, often of a conſiderable magnitude. They are priſms of ſix, eight, or ten unequal faces, truncated at right angles at their extremities. Theſe priſms are moſt commonly biſected lengthwiſe; and the

the large face, or baſe, on which they reſt, is marked by two diagonal lines, interſecting each other, and dividing the baſe into four triangles. The ſalt of Seignette, which ought to be called tartar of ſoda, was at firſt ſold as a ſecret, but was diſcovered, at the ſame time, by Boulduc and Geoffroy, in 1731. It has a bitter taſte; is decompoſed by the fire, like the tartar of pot-aſh; effloreſces in the air, becauſe it contains much water of cryſtallization, and is nearly as ſoluble as tartar of pot-aſh, and, like that ſalt, is decompoſed by mineral acids and metallic ſolutions. The mother water of this ſalt, contains the portion of tartar of pot-aſh, which compoſes part of the cream of tartar.

The volatile alkali forms, with cream of tartar, an ammoniacal tartareous ſalt, which cryſtallizes very well by evaporation and cooling. Bucquet affirms, that its cryſtals are rhomboidal pyramids. Macquer obſerved ſome, in thick priſms, of four, five, or ſix ſides; others thickeſt in the middle, and terminated by very acute points. The academicians of Dijon obtained them in oblique angled parallelopipedons. Ammoniacal tartar has a cool taſte, and is decompoſed by heat: in the air it effloreſces: hot water diſſolves it more readily than cold; and it cryſtallizes by cooling. Lime and fixed alkalis

alkalis diſengage the volatile alkali; mineral acids and metallic ſolutions decompoſe it.

Pott and Margraaf treated cream of tartar with the mineral acids, and the latter obtained neutral ſalts, ſimilar to thoſe afforded by each of theſe acids with vegetable alkali; whence he concluded, that this alkali exiſts, ready formed, in cream of tartar. Rouelle the younger made a number of accurate experiments, which afforded the ſame reſults. A pound of cream of tartar, in very fine powder, was added to a pound of oil of vitriol; the mixture became hot, and the mutual action of the two ſubſtances on each other was aſſiſted by the heat of a water-bath, and by frequent ſtirring with a glaſs inſtrument. This heat being continued ten or twelve hours, the mixture became of the thickneſs of cream, at which period two or three ounces of boiling diſtilled water were added, which rendered the whole fluid. Two hours after, the mixture was taken from the fire, and three pints of boiling diſtilled water were added. This ſolution was coloured, and opake, and contained diſengaged vitriolic acid, a portion of cream of tartar not decompoſed, and vitriol of pot-aſh. The exceſs of vitriolic acid was then ſaturated with chalk; and ſelenite, with a ſmall quantity of cream of tartar, were precipitated. The mixture was then filtered and evaporated, till it became reduced to eighteen or twenty

ounces;

ounces; during which, a ſmall quantity of cream of tartar and of ſelenite, fell down. The fluid was decanted off, evaporated a ſecond time, and by ſtanding afforded vitriolated tartar; more of which was obtained in the like manner by ſucceſſive evaporations. This ſalt is always mixed with a ſmall quantity of cream of tartar, and burns on a hot iron. But if a due quantity of diſtilled water be added, the vitriolated tartar will be taken up, and the cream of tartar will remain undiſſolved. The foregoing proceſs is deſcribed by Berniard, who repeated it with ſucceſs after Rouelle.

The nitrous and muriatic acids, treated in the ſame manner with cream of tartar, afford nitre and febrifuge ſalt; which incontrovertibly proves the exiſtence of vegetable alkali in this ſubſtance.

Cream of tartar acquires ſolubility, by uniting with borax and ſedative ſalt. According to the experiments of M. De Laſſone, one part of the latter ſalt may render about four parts of cream of tartar ſoluble. This mixed ſolution affords a greeniſh, very acid gummy ſalt, by evaporation.

Cream of tartar appears capable of uniting with moſt metallic ſubſtances, as Meſſrs. Monnet and the chemiſts of the academy of Dijon have ſhewn. But as theſe combinations have been little examined, we ſhall only ſpeak, in this place, of thoſe of antimony,

mony, mercury, lead, and iron; becauſe they are better known, and are moſt of them uſed in medicine.

The combination of cream of tartar and antimony, is called ſtibiated, or antimoniated tartar, or more commonly emetic tartar. As it is one of the moſt important remedies afforded by chemiſtry, it is neceſſary to examine its properties with the greateſt care. Since the time of Adrian de Mynſicht, who firſt deſcribed this compoſition, in the year 1631, the proceſs for making it has been greatly varied. The Pharmacopeia, and the writings of chemiſts, all differ, either in the antimonial ſubſtances directed to be employed, as well as in the cream of tartar and water, either with reſpect to quantity, or the method of applying them to each other. Bergman, in his diſſertation on this medicine,* has given an excellent ſection on the different proceſſes heretofore uſed in preparing antimoniated tartar. The crocus metallorum, the liver, the glaſs, and the flowers of antimony, have been ſucceſſively preſcribed: ſome direct theſe ſubſtances to be boiled with cream of tartar, and a greater or leſs quantity of water, for ten or twelve hours; others direct the ebullition to be continued no longer than half an hour; others again require the filtrated lixivium to be evaporated

* Eſſays, Vol. I.

to

to dryneſs; and laſtly, there are others who direct it to be cryſtallized, and the cryſtals only to be uſed in medicine. Hence it happens, that antimoniated tartar is never the ſame ſubſtance, but poſſeſſes various degrees of force, ſo that its effects cannot be clearly aſcertained. And accordingly Geoffroy, who examined many ſpecimens of antimoniated tartar, of different degrees of force, found, by the analyſis, that the weakeſt contained from thirty to ninety grains of regulus, in the French ounce of 576 grains. Thoſe of a middle degree of emetic power, 108 grains, and the ſtrongeſt 154 grains. Glaſs antimony has been choſen in preference to other antimonial ſubſtances, becauſe it is one of the moſt ſoluble by cream of tartar; but this glaſs may be more or leſs calcined, and the different degrees of calcination muſt affect its emetic power. However, if very tranſparent glaſs of antimony, previouſly well levigated, be boiled in water, with an equal weight of cream of tartar, till the latter is ſaturated, and this ſolution be filtered and evaporated by a gentle heat, cryſtals of antimoniated tartar are obtained, by ſtanding, whoſe emetic power appears to be ſufficiently conſtant. The liquor being decanted and evaporated, affords new cryſtals for ſeveral ſucceſſive times. The mother water contains ſulphur, tartar of pot-aſh, and a certain quantity of liver of ſulphur. When the mixture of cream of tartar, glaſs of

of antimony, and water, which has been boiled for the preparation of antimoniated tartar, is paſſed through the filtre, a yellow or brown gelatinous ſubſtance remains behind, which Rouelle has examined, and finds to afford, by diſtillation, a very inflammable pyrophorus.

Macquer propoſes to ſubſtitute the powder of algaroth, inſtead of glaſs of antimony, in the preparation of emetic tartar; becauſe this powder is itſelf a violent emetic, and when precipitated from the butter of antimony is always the ſame. Bergman has adopted the opinion of Macquer; and ſince that time, emetic tartar has been prepared in the laboratory of the academy of Dijon according to the method of Bergman and M. De Laſſone. This medicine has been uſed with the greateſt ſucceſs: it operates, in a doſe of three grains, without fatiguing the ſtomach or inteſtines.

Antimoniated tartar cryſtallizes in very tranſparent trihedral pyramids, decompoſable by heat, which converts them to a coaly ſubſtance. It effloreſces in the air, and becomes a white farinaceous powder; it is ſoluble in ſixty parts of cold water, or in a much leſs quantity of hot water. It cryſtallizes by cooling; and is decompoſed by lime and alkalis. Calcareous earth, and pure water, in a large doſe, are capable of decompoſing it; whence it follows, that it ought to be adminiſtered only in diſtilled water. Liver of ſulphur, and hepatic

hepatic gas, precipitate from it a red powder, or kind of golden ſulphur, which may ſerve as a teſt for the preſence of this ſalt in all liquors containing it. Iron ſeizes the acid of tartar, and ſeparates the calx of antimony; antimoniated tartar ought not, therefore, to be prepared in veſſels of this metal. Mr. Durande, phyſician and profeſſor at Dijon, propoſes that this medicine be made publickly, and by one uniform proceſs, eſtabliſhed by law, as the theriaca is made; and we are convinced, that the greateſt advantages would ariſe to the practice of phyſick from ſuch a regulation being adopted.

The tartareous acid may be combined with mercury by two methods. The one mentioned by Mr. Monnet, conſiſts in diſſolving ſix parts of cream of tartar in boiling water, with one part of mercury, precipitated from the nitrous acid by cretaceous vegetable alkali. This liquor, filtered and evaporated, affords cryſtals, that are decompoſable by pure water. The ſecond method of uniting mercury with the tartareous acid, conſiſts in pouring a nitrous ſolution of this metal into a ſolution of tartar of pot-aſh, or tartar of ſoda: a precipitate of mercurial tartar is afforded, and the nitre of pot-aſh, or ſoda, remains diſſolved in the liquor.

Cream of tartar has a ſenſible action on the calces of lead. Rouelle the younger has aſcertained, that the ſaturnine tartar, pro-

duced in this operation, does not remain diſſolved, but that the liquor, by evaporation, affords pure vegetable alkali, which was ready formed in the cream of tartar. This is one of the proceſſes he has made uſe of to prove that fixed alkali exiſts in tartar.

Copper, and its calces, are readily attacked by the tartareous acid: the reſult is a ſalt, of a beautiful green, capable of cryſtallization, but hitherto little examined.

Iron is very ſtrongly acted on by cream of tartar. A medicine, called chalybeated tartar, is prepared, by boiling eleven ounces of levigated iron filings with one pound of white tartar, in twelve pounds of water. When the tartar is diſſolved, the liquor is filtered, and depoſits cryſtals, more of which may be obtained by ſubſequent evaporation. To prepare the tartarized tincture of Mars, a paſte is made, with ſix ounces of iron filings, one pound of white tartar in powder, and a ſufficient quantity of water. This mixture is left at reſt for twenty-four hours; after which twelve pounds of water are added, and the whole boiled for two hours; freſh water being added in proportion as the evaporation goes forward. The liquor is then decanted, filtered, and thickened, by boiling to the conſiſtence of ſyrup; after which one ounce of ſpirit of wine is added. Rouelle aſcertained, that the fixed vegetable alkali exiſts at liberty in this tincture, and that by

heating

heating it with acids, neutral ſalts, with baſe of this alkali, are obtained. There are likewiſe two other, medical preparations, formed by the combination of the tartareous acid and iron. The one is ſoluble martial tartar, conſiſting of one pound of the tartarized tincture of Mars, and four ounces of tartar of pot-aſh, evaporated to dryneſs. The other is known by the name of martial balls. They are made by mixing, in a glaſs veſſel, one part of ſteel filings, and two parts of white tartar in powder, with a certain quantity of brandy; when the brandy is evaporated, the maſs is pulverized, and more brandy added, which is ſuffered to evaporate as before. This proceſs is repeated till the maſs becomes tenacious, when it is formed into balls.

Crude tartar is very uſeful in the art of dying, and it is likewiſe made uſe of by hatmakers.

The different preparations of cream of tartar which we have enumerated, are moſtly uſed in medicine; pure cream of tartar is conſidered as cooling and antiſeptic. In the doſe of half an ounce, or an ounce, it purges gently, and without exciting nauſea. The tartars of pot-aſh and of ſoda are often uſed, in conjunction with other purgative medicines, in the doſe of a few drachms: antimoniated tartar is one of the moſt uſeful and efficacious medicines afforded by chemiſtry. This ſalt is emetic, purgative, diuretic, diapho-

 retic,

retic, or deobſtruent, according to the doſes and proceſſes uſed in adminiſtering it. It often produces all theſe effects at one time. It may alſo be conſidered as a powerful alterative, of excellent uſe in removing obſtructions of the viſcera, when given in ſmall doſes often repeated. It is adminiſtered as an emetic, in the doſe of from one to four grains, diſſolved in water. It is mixed, in the doſe of a grain, with other purgatives, whoſe action it aſſiſts: and laſtly, when given in the quantity of half a grain, greatly diluted with water, it acts as an alterative. M. De Laſſone has diſcovered, that antimoniated tartar is rendered very ſoluble in water by the mixture of ſal ammoniac; and that a mixed ſalt, ſimilar to ſal alembroth, is produced. It may be concluded, that this new compound is capable of producing conſiderable effects on the animal economy.

Chalybeated tartar, ſoluble martial tartar, and the tartarized tincture of Mars, are uſed as tonic and aperient medicines.

CHAP.

C H A P. XXIII.

Of the Acid Fermentation, and of Vinegar.

MANY vegetable ſubſtances, ſuch as gums and amylaceous fecula, diſſolved in boiling water, are capable of undergoing the acid fermentation; but this property is more eſpecially remarkable in fermented and ſpirituous liquors. All theſe fluids, when expoſed to heat in contact with air, undergo the acid fermentation, and afford the liquor called vinegar. The wine of grapes is more eſpecially uſed in preparing this liquor, though it is poſſible to make very good vinegar with cyder, perry, &c.*

There are three conditions neceſſary to the acetous fermentation: 1. A degree of heat from 75° to 90° of Fahrenheit. 2. A ſubſtance at the ſame time viſcous and acid, ſuch as mucilage and tartar. 3. The contact of air. The change which wine undergoes, when it becomes converted into vinegar, muſt be attributed to an inteſtine motion, excited in the fluids by the preſence of a certain quantity of

* Vinegar is made in Britain from wort, which is the infuſion of malt, made in the ſame way as in the proceſs of brewing. T.

mucilage, which is not changed, and is capable of paſſing through a new fermentation. The preſence of an acid ſubſtance, ſuch as tartar, is neceſſary to determine the acid fermentation. Laſtly, the contact of air is indiſputably neceſſary, and it appears that a certain portion is abſorbed during this fermentation, as the Abbé Rozier has proved.

All wines are capable of forming vinegar. The bad wines are employed in preference, for the ſake of cheapneſs; but the experiments of Beccher and Cartheuſer, prove, that generous wines, abounding with ardent ſpirit, afford in general the beſt vinegar.

Boerhaave, in his Elements of Chemiſtry, has deſcribed a very good proceſs for making vinegar. Two large caſks are provided, and a falſe bottom of wicker is fixed, at ſome diſtance from the bottom, within each, on which vine branches and grape ſtalks are ſpread: wine is then poured in; ſo that one of the veſſels is filled, and the other only half full. The fermentation commences in the latter: when it is well eſtabliſhed, it is filled up with wine added from the other tun. By this means, the fermentation is retarded in the full veſſel, and accelerated in the other. When it has arrived at a conſiderable degree in this laſt, it is again filled up, by transferring part of the fluid from the other; the fermentation conſequently recommences in

in the veſſel from which the liquor was laſt taken, and becomes ſlower in that which is filled up. The alternate filling and emptying of the veſſels is continued till the vinegar is perfectly formed, which uſually happens in twelve or fifteen days.

When the effects of this fermentation are attend to, much ebullition and hiſſing is perceived; the liquor becomes hot and turbid, exhibits a great quantity of filaments and bubbles, agitated in every direction; a ſtrong acid ſmell, not at all dangerous, is emitted, and a large quantity of air is abſorbed. It is neceſſary to impede the fermentation every twelve hours. Theſe phenomena gradually become leſs, the heat decreaſes, the motion decays, and the fluid recovers its tranſparency: a ſediment is depoſited, in reddiſh flocks, which adhere to the ſides of the veſſels. Numerous experiments have ſhewn, that the ſmaller the quantity of wine, and the more perfect the acceſs of air, ſo much the more readily does it paſs to the ſtate of vinegar. The vinegar muſt be carefully drawn off, in order to ſeparate it from its lees, which, without this precaution, would quickly cauſe it to undergo the putrid fermentation. Vinegar does not depoſit tartar by ſtanding, like wine; this ſalt is diſſolved, and combined with the ardent ſpirit and water during the fermentation. It is

even probable, that the preſence of this ſalt contributes to the taſte and other acid properties of vinegar. This fluid has more or leſs of colour, according to that of the wine uſed in its preparation; but in general, vinegars, which have the leaſt colour, are far from being of as light a colour as the white wines, becauſe they hold in ſolution the colouring matter of the tartar, which has likewiſe been developed by the production of the acid.

Vinegar, prepared in the method here deſcribed, is very fluid; of an acid and ſpirituous ſmell; and of a ſour taſte, of different degrees of ſtrength: it reddens blue vegetable colours. When expoſed to a warm temperature, in imperfectly cloſed veſſels, it becomes changed, loſing its ſpirituous part, and depoſiting a great quantity of mucilaginous flocks and filaments, at the ſame time that it aſſumes a putrid ſmell and taſte. In order to preſerve it, it is neceſſary to boil it for a ſhort time, as Scheele has obſerved.*

When vinegar is diſtilled by a naked fire, in an earthen alembic, or in a glaſs retort, on a ſand-bath, a phlegm, of a lively and agreeable ſmell, but ſcarcely acid, firſt paſſes over; this is ſucceeded by a very white and odorous liquor, called diſtilled vinegar. The following products have leſs ſmell, and more acidity, as the diſtillation advances. If theſe

* This diſcovery, announced in Scheele's Eſſays, p. 315, Engliſh tranſlation, did not ſucceed with me upon trial. T.

pro-

products be taken ſeparately, diſtilled vinegars, differing from each other in acidity and ſmell, may be obtained; but it is uſual, in this proceſs, to draw off about two-thirds of the liquor, which conſtitutes the pureſt vinegar. The portion which comes over afterwards is more acid, but it has an empyreumatic ſmell, which may be diſſipated by expoſure to air; it is likewiſe ſlightly coloured. This operation ſhews, that the acetous acid is leſs volatile than water. The remaining vinegar is thick, of a deep and dirty colour, depoſits a certain quantity of tartar, and is conſiderably acid. If it be evaporated in open veſſels, it takes the form of an extract; and if, when dried, it be diſtilled in a retort, it affords a reddiſh phlegm, acid, an oil at firſt light coloured and afterwards heavy, with a ſmall quantity of volatile alkali. The remaining coal contains much fixed alkali.

Vinegar may be concentrated by expoſing it to froſt. The frozen part conſiſts almoſt intirely of water; the part which remains fluid, being decanted off, is found to be much more acid: the quantity of vinegar thus obtained is ſmall.

The acid of vinegar, ſeparated from tartar and the colouring matter, by diſtillation, is capable of uniting with a great number of bodies.

It does not readily combine with argillaceous earth, with which it forms cryſtals, in

in ſmall needles, whoſe properties are little known. It is the acetous ſalt of clay.

This acid unites readily with magneſia, and affords a ſalt, which is very ſoluble in water, and does not afford cryſtals, but is converted into a viſcous deliqueſcent maſs, by evaporation. The acetous ſalt of magneſia is decompoſed by fire, by the mineral acids, by ponderous earth, by lime, and by the alkalis. It is very ſoluble in ſpirit of wine.

The acid of vinegar combines with lime, and decompoſes chalk, whoſe acid it diſengages, in the form of an elaſtic fluid. The ſalt it forms with lime, cryſtallizes in very ſmall priſms, of a ſattin appearance. The calcareous acetous ſalt is bitter, and ſour, and effloreſces in the air. Fire decompoſes it; its earth is ſeparated by fixed alkalis; and the mineral acids diſengage its acid.

The combination of the acid of vinegar with vegetable alkali, is called terra foliata tartari, and ought to be called, the acetous ſalt of pot-aſh. This ſalt is prepared, by pouring very pure diſtilled vinegar on white ſalt of tartar; the mixture is agitated, and the vinegar added, till the ſaturation is perfect, and the ſalt well diſſolved. It is proper to add an exceſs of acid. The liquor, being firſt filtered, is evaporated, by a gentle heat, in a veſſel of porcelain, or pure ſilver; and when it becomes thick, the evaporation is continued

nued to dryneſs, on a water-bath. By this means, a very white terra foliata is obtained. If too ſtrong a degree of heat be uſed, it becomes grey, or brown, by the burning of a portion of the vinegar. Some chemiſts affirm, that this ſalt may be obtained in a regular form, by cooling the ſolution previouſly evaporated to a thick pellicle. The acetous ſalt of pot-aſh has a penetrating, acid, and urinous taſte. It is decompoſed by the action of fire; and affords, by diſtillation in a retort, an acid phlegm, empyreumatic oil, volatile alkali, and a large quantity of ſtrong-ſmelling gas, conſiſting of a mixture of cretaceous and inflammable gas. The reſidual charcoal contains much diſengaged fixed alkali. This ſalt ſtrongly attracts the humidity of the air, and is very ſoluble in water. The vitriolic acid decompoſes it. For this purpoſe, one part of oil of vitriol is poured on two parts of the acetous ſalt of pot-aſh, introduced into a tubulated retort, to which a receiver is adapted: a vaporous fluid, of a penetrating ſmell, is immediately diſengaged, with a ſtrong effervеſcence, which condenſes in the receiver, into a liquor called radical vinegar. This vinegar is very concentrated, and ſtrongly acid; but it is not pure, as it always contains a certain quantity of ſulphureous acid, diſtinguiſhable by its ſmell. Cream of tartar likewiſe decompoſes the acetous ſalt of pot-aſh, becauſe it has a ſtronger affinity

affinity than the acetous acid with the alkaline baſe of this ſalt.

Vinegar unites perfectly with ſoda, and forms a ſalt, improperly called cryſtallizable terra foliata. This does not differ from the acetous ſalt of pot-aſh, but in its cryſtallizing in ſtriated priſms, reſembling thoſe of the vitriol of ſoda, and in its not attracting the humidity of the air. To obtain perfect cryſtals, the ſolution muſt be evaporated to a pellicle, and ſet in a cool place. The acetous ſalt of ſoda is decompoſed by fire, and the mineral acids; and we may obſerve, that if the calcareous, or alkaline acetous ſalts, be diſtilled by a ſtrong heat, the reſidues are pyrophori, which take fire when expoſed to the air. Mr. Prouſt, the diſcoverer of theſe facts, is of opinion, that a pyrophorus is produced in all caſes, where a carbonaceous reſidue is divided by an earth or a metallic calx.

The acid of vinegar, with the volatile alkali, forms a liquor, known by the name of ſpirit of Mindererus. This ſalt is ſo volatile, that it cannot be evaporated without loſing the greateſt part of it. Nevertheleſs, cryſtals, in the form of needles, and of a hot and penetrating taſte, may be obtained by ſlow evaporation. The ammoniacal acetous ſalt is decompoſed by the action of fire, by lime and fixed alkalis, which diſengage the

volatile

volatile alkali, and by the mineral acids, ſeparate the vinegar.

Vinegar acts on almoſt all metallic ſubſtances, and its combinations are attended with a variety of important phenomena.

It does not appear to diſſolve the calx of arſenic; but this laſt ſubſtance diſtilled with an equal part of the acetous ſalt of pot-aſh, afforded Meſſrs. Cadet, and the chemiſts of the Academy of Dijon, a red fuming liquor of a nauſeous ſmell, very tenacious, and of a ſingular nature. Mr. Cadet had before obſerved, that this liquor inflames fat lute. The academicians of Dijon being deſirous of examining a yellowiſh matter of an oily conſiſtence, collected at the bottom of the veſſel, which contained the arſenico-acetous, fuming liquor, decanted a portion of this ſuperfluent liquor, and poured the reſt on a filter of paper. A few drops had ſcarcely paſſed, when immediately an offenſive and very thick fume aroſe, which formed a column from the veſſel to the cieling; a kind of ebullition was excited on the borders of the matter, and a beautiful roſe-coloured flame iſſued forth; all which laſted a few ſeconds. A full account of the experiments of theſe learned Academicians, may be ſeen in the third volume of the Elements of Chemiſtry of Dijon. They compared the liquor we have ſpoken of to a liquid phoſphorus; we think it is a pyrophorus of the

the ſame kind as thoſe we ſhall preſently mention. The reſidue of the diſtillation of the acetous ſalt of pot-aſh with calx of arſenic, conſiſts for the moſt part of vegetable fixed alkali.

Vinegar diſſolves the calx of cobalt, and forms a ſolution of a pale roſe colour.

It has no action on biſmuth, or its calces.

It diſſolves nickel directly, according to Mr. Arvidſon; this ſolution affords green cryſtals, of the form of a ſpatula.

The acetous acid does not appear to act on the regulus of antimony, but it appears to diſſolve the glaſs of this ſemi-metal; ſince Angelus Sala made an emetic preparation with theſe two ſubſtances.

Zink, and alſo its calces, are readily diſſolved by vinegar. Mr. Monnet obtained cryſtals from this ſolution in the form of flat plates. The acetous ſalt of zink fulminates on hot coals with a blueiſh flame. By diſtillation it affords an inflammable liquor, a yellowiſh oily fluid, which ſoon becomes of a deep green; and a white ſublimate, which when ſet on fire by a candle, burns with a beautiful blue flame; the reſidue is in the ſtate of a pyrophorus, not very combuſtible.

The acid of vinegar does not diſſolve mercury in its metallic ſtate; but this combination may be made by dividing the mercury into very ſmall particles, as was

done

done by Keyſer. Mercury, in the ſtate of calx, readily unites with vinegar. The acid may be boiled either on precipitate per ſe, on turbith mineral, or mercury precipitated from its nitrous ſolution by the vegetable alkali. The fluid becomes white, but recovers its tranſparency when boiling hot; it is then to be filtered, and ſilver-coloured cryſtals fall down, in ſcales reſembling ſedative ſalt. This has been called mercurial foliated earth, or mercurial acetous ſalt. It may be immediately prepared by pouring a nitrous ſolution of mercury into an acetous ſolution of vegetable alkali; the nitrous acid unites with the fixed alkali of this laſt ſalt, and forms nitre, which remains diſſolved; while the calx of mercury, combining with the acid of the vinegar, is precipitated in the form of brilliant ſcales. The mixture being then filtered, the mercurial acetous ſalt will remain on the filter. This ſalt is decompoſed by the action of fire, and its reſidue affords a kind of pyrophorus. It is quickly altered by combuſtible vapours.

Tin is not much altered by vinegar. This acid diſſolves only a ſmall quantity of that metal, which by ſolution afforded Mr. Monnet a yellowiſh ſubſtance reſembling gum, and of a fetid ſmell.

The acid of vinegar acts more ſtrongly on lead than on moſt other metals, and diſſolves it with the utmoſt facility. When thin plates of this metal are expoſed to the

the vapour of heated vinegar, they become covered with a white powder called ceruſe, which is a calx of lead. Ceruſe ground with one third part of chalk, forms the white lead uſed as a paint. In order to ſaturate vinegar with lead, the acid is poured on ceruſe in a matraſs; the mixture is ſet to digeſt on a ſand bath, and after ſeveral hours is evaporated to a pellicle; by cooling it affords white cryſtals, forming either irregular needles, if the fluid has been too much concentrated; or flat parallelipipedons, terminated by two ſlant ſections, when the evaporation has been well made. This is called ſalt or ſugar of Saturn, on account of its ſweet taſte, which is at the ſame time very ſtyptic. A ſalt of the ſame nature is made, by boiling equal parts of litharge and of vinegar, and evaporating it to the conſiſtence of ſyrup. This is the extract of Saturn of Mr. Goulard, which long before his time was known by the name of vinegar of Saturn. Salt of Saturn, or the acetous ſalt of lead, is decompoſed by heat; it affords an acid, ruddy, and very fetid liquor, different from radical vinegar. The reſidue is a very good pyrophorus. This ſalt is decompoſed by diſtilled water, by lime, by alkalis, and by the mineral acids. The extract of Saturn, diluted with water, and mixed with a ſmall quantity of brandy, forms the vegeto-mineral water.

Vinegar

Vinegar quickly diſſolves iron; the effervescence which takes place in this ſolution ariſes from the diſengagement of inflammable gas afforded by the water, which ſeems to be decompoſed. The liquor has a red or brown colour; and by evaporation affords only a gelatinous magma, together with ſome long brown cryſtals. The Martial acetous ſalt has a ſtyptic and ſweetiſh taſte; is decompoſed by fire, which drives off its acid; attracts the moiſture of the air, and is decompoſed in diſtilled water. When heated till it no longer emits a ſmell of vinegar, it leaves a yellowiſh calx attracted by the load-ſtone. The acetous ſolution of iron affords a very black ink with nut-galls, and may be ſucceſsfully uſed in dying. The phlogiſticated alkali precipitates a very bright Pruſſian blue. Martial æthiops, the precipitates of iron, the ſaffrons of Mars, the ſparry iron ore, afford ſolutions with vinegar of a very fine red colour.

Diſtilled vinegar diſſolves copper with very great facility, and by the aſſiſtance of heat it gradually aſſumes a green colour. But the acid acts more readily on this metal when already calcined by vinegar, and converted into the ſubſtance called verdigris. Verdigris is prepared in the neighbourhood of Montpellier, by plates of copper in earthen veſſels, covered in layers with the huſks of grapes, which have been previouſly ſprinkled

and fermented with weak vinegar. The ſurface of theſe plates ſoon become covered with a green ruſt, which is increaſed by piling them together, and ſprinkling them with weak vinegar. The copper is then ſcraped, and the verdigris is packed in ſacks of leather for ſale. M. Monnet, apothecary at Montpellier, has very well deſcribed this proceſs, in two Memoirs printed among thoſe of the Academy of Sciences, for the years 1750, and 1753. Verdigris readily diſſolves in vinegar, and the ſolution, which is of a beautiful green colour, affords by evaporation and cooling, green cryſtals, in truncated quadrangular pyramids, called cryſtals of Venus. The cryſtals prepared for commerce, which are called diſtilled verdigris, becauſe diſtilled vinegar is uſed in preparing them, have the figure of a pyramid; its cryſtals aſſume this form, becauſe they are depoſited on a ſtick cleft into four branches, which are kept aſunder by a piece of cork.

The acetous ſalt of copper has a ſtrong taſte, and is a violent poiſon. It is decompoſed by the action of fire, effloreſces in the air, and becomes covered with a powder, whoſe green colour is much paler than that of the ſalt itſelf. It is completely diſſolved in water without decompoſition. Lime-water and alkalis precipitate the calx of copper.

When

When this ſalt is pulverized and diſtilled in an earthen or glaſs retort, a fluid is obtained at firſt pale and ſcarcely acid; but affords afterwards one ſo ſtrong, as to reſemble the mineral acids. The receiver muſt be changed during the operation, in order that the phlegm and the acid may be had ſeparate; the latter is called radical vinegar. It has a green colour, ariſing from a certain quantity of the calx of copper which comes over. When the diſtillation ceaſes, and the bottom of the retort is red hot, the reſidue is a brown copper coloured powder, which often communicates a metallic tinge to the ſides of the veſſel. This reſidue is ſtrongly pyrophoric, as the Duc D'Ayen and Prouſt have obſerved. Radical vinegar is rectified by diſtillation with a gentle heat; it is then perfectly colourleſs, provided the heat has not been urged too ſtrongly, ſo as to dry the remaining calx of copper. The reduction of the copper reſerved in this experiment explains the nature of radical vinegar. This acid appears to have the ſame relation to common vinegar, as the aerated or oxyginated muriatic acid has to the pure muriatic acid. In this operation the acetous acid unites with the oxyginous principle of the calx of copper, which at the ſame time reſumes the metallic ſtate. The very different effects produced by radical vinegar, compared with thoſe of the common acetous

acid, appear therefore to arise from its excess of the oxyginous principle.

Radical vinegar, thus rectified, has so strong and penetrating a smell, that it is impossible to support it for any length of time; its causticity is such, that it corrodes and burns the skin, and it is extremely volatile and inflammable. When heated with contact of air, the rapidity with which it burns is the greater, the more highly it is rectified. This experiment has induced chemists to believe, that vinegar is an acid combined with an ardent spirit; it may, perhaps, be considered as a kind of natural ether. This notion is rendered probable, by the penetrating and agreeable smell emitted by the first portions of this acid in distillation. Radical vinegar evaporates intirely, when exposed to the air; it unites to water, with much heat; with earths, alkalis, and metals, it forms the same salts as common vinegar; but its action on combustible bodies is in general much more rapid. The Marquis de Courtanvaux has shewn, that it is only the last portion of the acetous fluid obtained by distillation from crystals of verdigris which is inflammable; and that it likewise has the property of being congealed by cold. This last portion when rectified, crystallized in the receiver in large plates and needles, and did not become fluid, at a less heat than about 62 degrees

degrees of Fahrenheit. In this property likewiſe it reſembles the aerated muriatic acid.

The acid of vinegar, aſſiſted by heat, diſſolves the precipitate of gold made from aqua regia by adding a fixed alkali. This ſolution, precipitated by volatile alkali, affords fulminating gold, as Bergman has ſhewn. Vinegar does not act on platina or ſilver, while they are in the metallic ſtate, but it diſſolves their calces.

This acid combines with many of the immediate principles of vegetables. It diſſolves extracts, mucilages, and eſſential ſalts; unites with the ſpiritus rector, and is conſidered as the proper ſolvent of gum reſins. It has even after a certain length of time in the way of diſtillation, a conſiderable action on fat oils, which it converts into a ſaponaceous ſtate. But the combination of vinegar with vegetable ſubſtances, has been by no means accurately examined.

This acid is uſed to extract ſome of the vegetable principles, more eſpecially that of ſmell; and vinegars of different nature, either ſimple or compound, are prepared for medical uſe. The vinegars of ſquills, colchicum, &c. afford an example of the firſt; the theriacal vinegar, and the vinegar of the four thieves, are of the ſecond kind. Theſe medicines are prepared by maceration and digeſtion continued for ſeveral days. As the acid is volatile, it is diſtilled from aromatic

plants, whoſe odorant principle it takes up; the diſtilled vinegar of lavender uſed as a perfume is of this kind; theſe liquors are in general leſs agreeable than ſpirituous diſtilled waters.

Radical vinegar decompoſes ſpirit of wine, and forms ether with the ſame facility as the mineral acids, as the Count de Lauraguais has diſcovered. For this purpoſe, radical vinegar is poured on an equal quantity of ſpirits of wine in a retort. A conſiderable degree of heat is excited. The retort is then placed in a ſand bath, with two receivers fitted on, the outer being plunged in cold water or pounded ice. The mixture being quickly brought to ebullition, a dephlegmated ſpirit of wine paſſes firſt, afterwards the ether, and laſtly an acid which is ſtronger as the diſtillation advances: a brown maſs, conſiderably reſembling a reſin remains in the retort. Care muſt be taken to change the receiver as ſoon as the etherial ſmell becomes ſharp and penetrating, that the acid may be collected apart from the ether. The ether muſt be rectified by a gentle heat with alkali. A large proportion is loſt in this operation. The formation of the acetous ether is owing to the exceſs of the oxyginous principle in radical vinegar. Mr. Scheele affirms, that he did not ſucceed in preparing acetous ether, by adding radical vinegar to ſpirit of wine, and that he did not obtain it, but by the addition of a mineral acid. Mr. Pœrner

ner had before made the ſame remark concerning the difficulty of obtaining acetous ether by the proceſs of Mr. de Lauraguais. However, many French chemiſts have executed that proceſs; and I can myſelf affirm, that I have repeated it with ſucceſs.

M. de la Planche, the apothecary, prepares acetous ether, by pouring oil of vitriol and ſpirit of wine on ſalt of Saturn, introduced into a retort. The theory and practice of this operation, are abſolutely the ſame as thoſe of the nitrous and muriatic ethers, prepared by a like proceſs.

The acetous ether has an agreeable ſmell like other ethers, but it always partakes of the ſmell of vinegar, though it is not acid. It is very volatile and inflammable, burns with a bright flame, and leaves a coaly mark after its combuſtion.

Vinegar is much uſed as to ſeaſon food. It is likewiſe of excellent uſe in medicine, as a refreſhing and antiſeptic fluid. A ſyrup is made with ſugar, which is given with great ſucceſs in burning or putrid fevers, &c.; this acid, externally applied, is aſtringent and bracing. All its combinations are likewiſe applied to medical uſes.

The acetous ſalts of vegetable and mineral alkali, which are known by the names of terra foliata tartari, and mineral acetous ſalt, are powerful deobſtruent and aperient remedies;

medies; they are adminiſtered in the doſe of from half a drachm to a drachm.

The ſpirit of Mindererus, or ſolution of ammoniacal acetous ſalt, taken in the doſe of a few drops in a proper liquid, is aperient, dieuretic, cordial, antiſeptic, &c. It often ſucceeds in the leucophlegmatia, or ſwelling of the external parts of the body.

The Mercurial acetous ſalt, or Mercurial terra foliata, is an excellent anti-venereal; it is the principal ingredient in Keyſer's pills.

The extract of Saturn, vinegar of Saturn, and the vegeto-mineral water are applied externally as deſiccatives. Theſe medicines, being ſtrongly repellent, ought to be adminiſtered with great caution, eſpecially when applied to parts which are ulcerated or without ſkin. Boerhaave mentions ſeveral young women attacked with conſumptions, in conſequence of the external uſe of preparations of lead.

Ceruſe enters into the compoſition of drying unguents and plaſters, and verdigris is a component part of ſeveral collyria and unguents.

Radical vinegar is uſed as a very powerful ſtimulant to be reſpired by ſuch as fall into fainting fits. For the convenient uſe of this remedy, a certain quantity is poured on vitriolated tartar groſsly powdered, which is kept in a well cloſed bottle; this medicine is

is univerſally known by the name of ſalt of vinegar.

Acetous ether has not yet been applied to any uſe; neither is it known whether it has any peculiar virtues, differing from thoſe of the other ethers.

CHAP. XXIV.

Concerning the Putrid Fermentation of Vegetables.

ALL the vegetable ſubſtances, which have paſſed the ſpirituous and acid fermentation, are ſuſceptible of a third inteſtine commotion, by which they are changed; this is called the putrid fermentation. Stahl, and ſeveral other chemiſts, have thought, that this kind of fermentation is merely a conſequence of the two preceding, or rather that theſe three phenomena depend on a ſingle proceſs, or motion, which tends to deſtroy the texture of ſolid ſubſtances, and to change the properties of fluids. It is true, in fact, that if certain vegetable ſubſtances be left to themſelves, they paſs through the three fermentations ſucceſſively, and without interruption. For example; all ſaccharine matters, diſſolved in a certain quantity of water,

water, and expofed to a degree of heat of about 60 or 80 degrees, afford, firft wine, afterwards vinegar, and at laft the acid character is deftroyed; they putrify, lofe all their volatile principles, and become dry, infipid, and earthy. But it muft be obferved, that a great number of vegetable fubftances do not pafs through thefe three kinds of fermentation, at leaft as far as fenfe can diftinguifh. Infipid mucilages, and folutions of gum in water, become four, without exhibiting any appearance of fpirit; and the glutinous matter appears to pafs immediately to putrefaction, without previoufly becoming acid. It therefore appears, that though thefe three fermentations fucceed each other in many of the vegetable principles, there are neverthelefs many others which are capable of the two laft, without the foregoing, or even of putrefying, without exhibiting previous figns of acidity. Thefe laft participate of the nature of animal fubftances, and afford volatile alkali by the action of heat, and mephitis by the nitrous acid. It appears to be from this character, that the vegeto-animal fubftances putrefy fo readily.

The inteftine motion which changes the nature of vegetable matters, and reduces them to their elements, requires the following conditions. Humidity, or the prefence of water, is one of the moft neceffary; dry and

and ſolid vegetables, ſuch as wood, are not at all changed, while they remain in that ſtate; but if they be moiſtened, and their fibres ſeparated, the inteſtine motion ſoon commences: water, therefore, appears to be one of the cauſes of putrefaction; and we ſhall ſee, in the animal kingdom, that the decompoſition of this liquid appears to produce fermentation. Heat is not leſs neceſſary. Cold, or the temperature of ice, not only oppoſes this ſpontaneous deſtruction, but retards its progreſs, and in ſome meaſure reſtores the former ſtate of ſubſtances which have began to change. The degree of heat, neceſſary to putrefaction, is much leſs than that which maintains the ſpirituous and acid fermentation, ſince it requires no more than about 45 degrees of temperature; but a ſtronger degree of heat is more favourable to this proceſs, provided it be not ſo ſtrong as to volatilize all the humidity, and intirely to dry the ſubſtance which putrefies. Acceſs of air is a circumſtance which ſingularly promotes putrefaction, ſince vegetable ſubſtances are very well preſerved in a vacuum. This preſervation, however, has its limits; and the contact of air does not appear to be indiſpenſable for carrying on putrefaction, like the two conditions before-mentioned.

The putrefaction of vegetables has its peculiar phenomena. Vegetable fluids, which putrefy, become turbid, loſe their colour, and depoſit

deposit different sediments; bubbles rise to the surface, and mouldiness appears at the beginning. Vegetable matters, simply moistened, and soft, exhibit the same phenomena; the commotion is never so great as in the spirituous and acetous fermentations. The bulk of the matter which putrefies does not appear to increase, neither does its temperature rise; but the most important phenomenon is the change of smell, and the volatilization of an acrid penetrating urinous principle, similar to the volatile alkali, and which, on examination, is found to be that substance. Hence the putrefactive fermentation has been distinguished by the name of the alkaline fermentation, and the volatile alkali has been considered as its product. The penetrating smell flies off by degrees, and is succeeded by a nauseous, faint smell, not easily described. The decomposition is then at its height; the putrefying vegetable matter is then very soft, or fluid, like a syrup; it experiences a great number of successive modifications in the odorant principle which exhales. Lastly, it dries, its disagreeable smell is dissipated by degrees, and nothing remains but a blackish, and as it were, coaly residue, known by the name of earth, humus vegetabilis, in which nothing is found but certain saline and earthy substances. Such is the order of the phenomena observed in the spontaneous decomposition

poſition of vegetables which putrefy: but this decompoſition, carried to that point in which bodies are reduced to their ſaline or earthy ſkeleton, requires a very long time; and it may even be added, that it has not yet been properly obſerved by any perſon. This reproach which is caſt on chemiſts and philoſophers for their inattention to animal matters, is much more deſerved with regard to vegetable ſubſtances. No philoſopher has yet undertaken to obſerve the complete putrefaction of theſe laſt, though many have begun to deſcribe the phenomena which take place in that of animal matters. We may therefore conclude the hiſtory of the ſpontaneous and natural analyſis of vegetables, by adding, ſimply, 1. That the ſhort account we have given ſhews, that vegetable putrefaction attenuates, volatilizes, and deſtroys their humours, and reduces them to the earthy ſtate. 2. That nothing is yet certainly known concerning the phenomena and limits of this kind of putrefaction, which requires to be properly diſtinguiſhed from that of animal matters. 3. Laſtly, as this fermentation is much more evident, and has been better obſerved in the fluids and ſolids of animal ſubſtances, the larger detail we ſhall enter into, reſpecting theſe laſt, will complete our hiſtorical ſketch of the known facts relating to putrefaction.

PART

P A R T IV.

The ANIMAL KINGDOM.

C H A P. I.

The General Characters of Animals.*

ANIMALS are in general diſtinguiſhed from vegetables, by locomobility, and more perfect organization. Yet, there are intire claſſes of theſe which are fixed to a place; ſuch as the lithophytes, and zoophytes, which are produced and die on the ſame ſpot. And, on the other hand, certain vegetables have as much motion in their leaves and flowers, as certain animals; for example, ſhell-worms. The organization

* We do not here propoſe to exhibit more than a ſketch of the methods of naturaliſts, to facilitate the progreſs of beginners in the ſtudy of natural hiſtory, as treated by the beſt writers: but our plan does not permit us to enter fully into general conſiderations on the nature of animals, which have been treated in ſo elegant and philoſophical a manner by the Count De Buffon and Mr. Bonnet. F.

even

even appears leſs perfect in polypi than in moſt plants. Hence it is very difficult to draw a true line of diſcrimination between theſe two kingdoms; and modern naturaliſts have therefore been under the neceſſity of confounding them in one ſingle arrangement, called the organic kingdom.

Nevertheleſs, when we conſider perfect animals, we find great differences between them and vegetables. Numerous and diſtinct organs, a more complicated ſtructure, and a greater variety of functions, are the characters in which theſe differences conſiſt; but it does not appear the leſs difficult to give a good definition of theſe ſubſtances.

By attending to the moſt general characters, we may define animals to be bodies endued with ſenſation and motion, neceſſary to preſerve their life. They are all capable of re-producing their like: ſome, by the union of the two ſexes, produce ſmall living creatures; others lay eggs, which require nothing more than a due temperature, in order to produce young. There are ſome which multiply without conjunction of ſexes; and others which are re-produced when cut in pieces, like the roots of plants. The true character, or ſpecific diſtinction of animals, is not eaſily aſſigned. The mixture of races produces numberleſs varieties; and tranſportation into different climates occaſions numerous changes in the form, magnitude,

nitude, colours, &c. of animals. We can only, therefore, conſider thoſe as diſtinct ſpecies, which have conſtantly the ſame form, and are perpetuated by the re-production of individuals; and the alterations produced by the intermixture of ſpecies, climate, domeſtication, &c. conſtitute the varieties.

The number of animals which cover the ſurface of our globe being very conſiderable, it would be impoſſible to diſtinguiſh them from each other, if nature had not preſented remarkable differences in their external figure, on which diſtinctions are eaſily eſtabliſhed. Naturaliſts have at all times been ſenſible of the utility of theſe differences, which they have advantageouſly applied in claſſing animals into methodical diviſions. Although it is certain, that theſe claſſifications do not exiſt in nature, but that the whole chain of created beings is uninterrupted, yet it is certain, that theſe methods aſſiſt the memory, and are of great uſe in the ſtudy of natural hiſtory. We may therefore conſider theſe methods, as inſtruments appropriated to our limited powers, by the help of which we may ſucceſsfully attend to the riches of nature. Ariſtotle eſtabliſhed only general and ſimple diviſions; but his maſterly conſiderations, reſpecting the interior and exterior organs of animals, have formed a baſe, on which the diviſions of the firſt naturaliſts, ſuch as Geſner, Aldrovandus, Jonſton,

Jonſton, Charleton, Ray, &c. are in great part founded. Theſe early naturaliſts have been ſucceeded by a great number of others, who have rendered the methods more perfect, and have added to the knowledge we poſſeſs; but among theſe laſt, thoſe whoſe works more particularly require to be known, and from whom we ſhall borrow, are Meſſrs. Klein, Artedi, Linnæus, Briſſon, Daubenton, Geoffroy.

After man, whoſe organization and intelligence place him at the head of animated bodies in a ſeparate claſs, all other animals may be divided into eight claſſes; namely, quadrupeds, cetacea, birds, viviparous quadrupeds, ſerpents, fiſhes, inſects and worms, and polypi. Theſe claſſes might be more multiplied, but the difficulties would increaſe in the ſame proportion, and defeat the purpoſe of artificial claſſification, whoſe ſole merit conſiſts in ſimplicity and perſpicuity. Mr. Daubenton, who has paid great attention to the claſſification of animals, has arranged them in the ſame manner, and has conſidered the ſtructure of the principal conſtituent parts of each, to ſhew that the claſſes are gradually degraded, from quadrupeds, which neareſt reſemble man, to worms, which are the moſt remote. See Table I.

CHAP. II.

Concerning Quadrupeds and Cetaceous Animals.

Zoology.

QUADRUPEDS are animals having four feet, whofe body is moft commonly covered with hair. They refpire by lungs fimilar to thofe of man; and like him they have a heart, confifting of two ventricles: they are viviparous. Thefe animals refemble man the neareft in their ftructure; there are even fome, as for example, the ape and a few others, which Linnæus has thought proper to include in the fame order as man. This naturalift gives the name of mammalia to this clafs, in which he comprehends cetaceous fifh, becaufe they have teats, and give milk to their young. Though this clafs of animals appears to refemble man in fome refpects, yet they differ greatly from him in feveral important particulars. Such are the horizontal fituation of their bodies, the form of their extremities, the thicknefs and hardnefs of their fkin, which is hairy, or covered with a hard and as it were corneous fubftance,

ſtance, the prolongation of the vertebræ of the back into a tail, the anterior part of the cranium flat and horizontal, the ears large and long, the bones of the noſe and upper jaw very long, and placed obliquely. When we compare this ſtructure to that of the human ſpecies, whoſe body is perpendicular, the bone called radius moveable, the fingers perfectly ſeparate, the thumbs oppoſed to the four other fingers, and the ſkin ſmooth and thin, we ſhall be ſenſible how much this conformation exalts its ſenſibility, and renders it ſuperior to the moſt perfect of other animals. The anatomy of its internal parts, and the hiſtory of its functions, add ſtill more force to thoſe important concluſions.

The ancient naturaliſts, at whoſe head Ariſtotle and Pliny may be placed, have diſtinguiſhed quadrupeds only by the place of their habitation. For which reaſon, and the want of accurate deſcriptions, it is often impoſſible to aſcertain the animals they ſpeak of. Later naturaliſts, perceiving the diſadvantages of this method, adopted another, which is very different; they have availed themſelves of the moſt obvious differences on the external parts of animals, to eſtabliſh characters readily known, by the aſſiſtance of which they may with certainty be diſtinguiſhed from each other. We ſhall in this place explain three artificial methods

of claſſing quadrupeds; namely, thoſe of Linnæus, Vogel, and Briſſon.

The Method of Linnæus.

Linnæus has divided animals with teats, or the mammalia, in ſeven orders. The firſt, comprehending thoſe which he calls primates, has for its characters inciſive teeth in both jaws; conſtantly four in number in the upper jaw; two teats on the breaſts, and the arms ſeparated by claviculæ: this order contains four genera; man, *homo*; the ape, *ſimia*; the lemur, or proſimia; and the bat, *veſpertillio*. It cannot but be admitted that this method is very remote from nature, ſince it arranges in the ſame order, creatures ſo diſſimilar as man and the bat.

Animals of the ſecond order are diſtinguiſhed by the name of bruta: their characters are the want of inciſive teeth, their feet armed with ſtrong hoofs, and their pace ſlow. This order includes ſix genera, which are the elephant, *elephas*; the ſea-cow, *trichecus*; the ſloth, *bradypus*; the ant-eater, *myrmecophaga*; the——— *manis*; the tatow, *daſypus*. The two firſt genera are very remote from the four others.

In the third order, the Swediſh naturaliſt diſtinguiſhes ſavage beaſts by the name of feræ. In this he comprehends all animals with teats, whoſe inciſive teeth are conical, and

and ufually fix in number in each jaw, whofe canine teeth are very long grinders, not flatted, feet armed with fharp nails, and which tear their prey, and live by deftroying other creatures. There are ten genera of this order; the feal, *phoca*; the dog, *canis*; the cat, *felis*; the ferret, *viverra*; the weazel, *muftela*; the bear, *urfus*; the opoffum, *didelphis*; the mole, *talpa*; the fhrew-moufe, *forex*; and the hedge-hog, *erinaceus*.

The fourth order, intitled glires, or rats, is diftinguifhed by the following characters: the animals which compofe it have two incifive teeth in each jaw, and no canine teeth; their feet are armed with claws proper for leaping; they live on barks, roots, &c. This order comprehends fix genera; namely, the porcupine, *hiftrix*; the hare, *lepus*; the caftor, *caftor*; the rat, *mus*; the fquirrel, *fciurus*; and the American bat, to which Linnæus has given the name of noctilio.

In the fifth order, he includes, under the name of pecora, fuch quadrupeds as have incifive teeth in the lower jaw, and none in the upper; whofe feet are cloven, and which ruminate. The camel, *camelus*; the mufk animal, *mofchus*; the ftag, *cervus*; the goat, *capra*; the fheep, *ovis*; the ox, *bos*; are the fix genera which compofe this order.

The fixth order includes, under the denomination of belluæ, fuch quadrupeds as have the incifive teeth obtufe, and their feet hoofed.

hoofed. The four genera of this order, namely, the horſe, *equus*; the hippopotamus, *hippopotamus*; the hog, *ſus*; and the rhinoceros, *rhinoceros*, are very well diſtinguiſhed from each other by the number of their teeth, and the form of their feet. Laſtly, in the ſeventh order, which comprehends the cetaceous animals, is diſtinguiſhed from all others by the form of the feet, which reſemble fins: but as we think proper, with many modern naturaliſts, to make a peculiar claſs of cetaceous animals, we ſhall ſpeak of them after quadrupeds.

The method of Linnæus appears to be defective in many reſpects; not only in its arranging together animals ſo diſſimilar as man and the bat, &c. and ſeparating animals ſo ſimilar as the rat and the mouſe, &c. but likewiſe becauſe the diviſions are not ſufficiently numerous, and do not readily enable us to diſtinguiſh each quadruped; which laſt requiſite is indiſpenſably neceſſary, and is in fact the only advantage a method is required to poſſeſs.

The Method of Klein.

Klein divides quadrupeds into two principal orders: in the firſt, he arranges thoſe whoſe feet are ungulated, *pedes ungulati ſive cheliferi*; in the ſecond, thoſe whoſe feet are digitated, *pedes digitati*.

The

The firſt order is divided into five families, whoſe characters are founded on the diviſion of their ungulated feet in ſeveral pieces. The firſt family, called *monochela*, comprehends the genus of the horſe: the ſecond, whoſe individuals are diſtinguiſhed by the name *dichela*, includes all thoſe whoſe feet are cloven into two parts, *biſulci*. Some have horns, as the bull, the ram, the goat, the ſtag, &c. others are not horned, as the hog, the boar, the babyrouſſa. The *trichela*, or animals, whoſe ungulated feet are divided into three parts, compoſe the third family, of which the rhinoceros is the only variety. The fourth family, whoſe character conſiſts in the feet being divided into four pieces, *tetrachela*, contains only the hippopotamus. The fifth, which is diſtinguiſhed by the feet being divided into five parts, *pentachela*, includes only the elephant.

The ſecond order of quadrupeds, whoſe feet are digitated, is likewiſe divided into five families; the firſt comprehending animals with two digits, *didactyla*, conſiſts of the camel and the ſilenus, or ſloth of Ceylon. The ſecond family, or animals of three digits on their feet, *tridactyla*, includes the ſlóth and the ant-eater. The third, or *tetradactila*, or animals of four digits, contains tatous, or armadillos, and Guinea pigs, which ſeem to be a ſpecies of rabbits. The fourth

 family,

family, characterized by five digits on the feet, *pentadactila*, is the most numerous of all; it contains the rabbit, the squirrel, the dormouse, the rat and the mouse, the opossum, the mole, the bat, the weazel, the porcupine, the dog, the wolf, the fox, the coati, the cat, the tyger, the lion, the bear, the ape: the number of species comprehended under these genera is very considerable. It must be observed, that in all these characters, taken from the form of the feet, Klein considers only the fore feet in his distinction of families. Lastly, the fifth family consists of animals whose feet are irregular, *anomalopedia*; such are the otter, the castor, the sea-cow, and the seal.

The same objection may be made to the system of Klein, as to that of Linnæus. Though his first divisions are sufficiently distinctive of the families, the genera are not so easily ascertained according to his method, more especially those of the fourth family.

The Method of M. Brisson.

M. Brisson has avoided most of these inconveniences, by combining together all the characters of the naturalists who have preceded him. He has availed himself of the number of teeth, or their absence, the form of the extremities, that of the tail, the nature

ture of the appendices, ſuch as the horns, the ſcales, the prickly ſpines or quills. His combined method is doubtleſs the moſt complete, and beſt adapted to diſtinguiſh any quadruped, and refer it to its proper genus. We here preſent his diviſions in the form of a table; it exhibits the characters of theſe animals to their reſpective genera, and has the advantage of being very ſimple, and eaſily underſtood. See Table II.

Concerning Cetaceous Animals.

Cetaceous animals are of a large ſize, inhabit the ocean, and by the ſtructure of their lungs and blood-veſſels, are capable of living in water, as we ſhall more fully explain in the hiſtory of reſpiration. They reſemble quadrupeds in the ſtructure of their breaſts, and in general of all their internal organs, as well as in their bringing forth living young. But they differ from them in the form of their extremities, which terminate in fins, and in two large apertures, at the upper part of their heads, through which they caſt up the water to various heights. Naturaliſts call theſe paſſages *ſpiracula*. The number of genera of theſe animals is much leſs conſiderable than that of quadrupeds. M. Briſſon has diſtinguiſhed them, 1. Into ſuch as have no teeth, as the whale, *balæna*.

balæna. 2. Into ſuch as have teeth only in the upper jaw, as the narwal, or unicorn fiſh, *monodon, vel monoceros*. 3. Such as have teeth only in the lower jaw, as the *phyſeter*. 4, and laſtly, Such as have teeth in both jaws, as the dolphin, *delphinus*.

C H A P. III.

Concerning Birds.

ORNITHOLOGY.

BIRDS are biped animals, which move through the air by means of wings, are covered with feathers, and have a beak of a horny ſubſtance. A great number of intereſting facts are obſervable with regard to theſe animals, relative to the various form of their beak, the ſtructure of their feathers, the motions they perform, and their manners or habits. The moſt important of theſe will be exhibited in the abridgment of phyſiology, which we ſhall give in the following pages; but at preſent we ſhall only attend to the external characters which naturaliſts have taken to diſtinguiſh birds, and claſs them methodically. The earlier writers on this part of natural hiſtory have eſtabliſhed

bliſhed no other differences between birds than ſuch as relate to the places they inhabit. Hence they have diſtinguiſhed them into birds inhabiting woods, plains, ſeas, rivers, lakes, &c. Others have diſtinguiſhed them from their food, into birds of prey, granivorous birds, &c. &c.

But the methodical writers have diſtinguiſhed birds in another way. Linnæus has divided them after the form of their beak into ſix orders, like the quadrupeds with which he has compared them. But theſe diviſions do not appear ſufficiently extenſive, eſpecially when we conſider that the number of ſpecies in birds is much more conſiderable than in quadrupeds, ſince M. de Buffon reckons the quadrupeds at two hundred, and the birds at fifteen hundred, or two thouſand. We ſhall therefore only mention in this place the methods of Klein and of Briſſon.

Klein divides birds into eight families, after the form of their feet; the firſt under the name of *didactiles*, comprehends ſuch as have two digits on their feet; the oſtrich is the only ſpecies in this diviſion. The ſecond contains the *tridactyles*, ſuch as the caſuary, the buſtard, the lapwing, and the plover. The third contains the *tetradactyles*, which have two digits behind and two before; ſuch as the parokeet, the wood-pecker, the cuckcow, and the king-fiſher. The fourth

fourth contains the *tetradactyles*, three of whose digits are before, and one behind. This family is the most numerous of any, as it comprehends the birds which prey by day and by night, such as the raven, the magpye, the starling, the thrush, the black-bird, the lark, the red-breast, the swallow, the titmouse, the woodcock, &c.

The fifth family contains the *tetractyles*, whose three anterior digits are united by a membrane, and the posterior at liberty. These birds are called *palmipedes*; the goose, the duck, the sea-maw, and the diver, compose this family. The sixth includes the *tetradactyles*, whose four digits are united by a membrane. These in latin are called *planci*. The pelican, the cormorant, the booby, and the anhinga, are arranged by Klein in this family. The seventh is composed of such as have only three digits, and these united by a membrane; they are called the *tridactyles palmipedes*. The guillemot, the penguin, and the albatros, belong to this family. Lastly, the eighth class includes the *tetradactyles*, whose digits have membranes fringed, or as it were torn; these are also called *dactylobes*. Coots, and some of the species of divers, compose this last family. The method of Klein, though more comprehensive than that of Linnæus, is notwithstanding attended with many difficulties in ascertaining the genera, especially that of

of the fourth family; for which reaſon we think the method of M. Briſſon is to be preferred. It muſt be confeſſed, however, that this laſt, in which the author has uſed all the characters together, as he has done with reſpect to the quadrupeds, appears very complicated at firſt ſight; but when it is reduced into a table, as we have done, all its diviſions may be readily diſtinguiſhed; and any bird may be eaſily known by attending to the characters according to their arrangement. See table the third at the end of this volume.

CHAP. IV.

Concerning Oviparous Quadrupeds, and Serpents.

LINNÆUS claſſed together, in his ſyſtem, under the denomination of amphibia, the oviparous quadrupeds, ſerpents, and cartilaginous fiſhes: but M. Daubenton obſerves, that the word amphibious cannot be applied to any peculiar claſs of animals; becauſe, if the expreſſion be applied to animals who live as long as they pleaſe either in the air or in the water, there are none which poſſeſs that advantage; and if

if it be applied to terreſtrial animals, which are able to remain a certain time in the water, or to aquatic animals, which are capable of living a certain time in the air, all animals would be amphibious. He therefore makes two orders of oviparous quadrupeds and ſerpents, and arranges the amphibia nantes of Linnæus among the fiſhes.

The oviparous quadrupeds form the fourth order of animals in the diviſion of M. Daubenton. Their organization is conſiderably perfect, ſince like the quadrupeds, cetaceous animals, and birds, which precede them, they have a head, noſtrils, and internal ears. But they differ in the following characters: 1. They have but one ventricle in the heart. 2. Their blood is almoſt cold. 3. They inſpire and expire the air at long intervals. 4. They are oviparous, and conſequently without breaſts; this laſt character is common to them with the four orders of animals which follow them. Laſtly, the exiſtence of four feet without hair, is peculiar to this order.

M. Daubenton remarks, that the ſeveral genera of this order of animals differ too much from each other, to admit of any general deſcription applicable to the whole. He therefore applies the general characters in the hiſtory of each genus; as for example, at the words tortoiſe, lizard, toad, frog, &c. in the ſecond volume of the Natural Hiſtory

Hiſtory of Animals, which compoſes part of the Encyclopédie Méthodique.

As the methodical diſpoſition, and the characters of the orders of oviparous quadrupeds, as laid down by this celebrated naturaliſt, are the moſt accurate and complete of any which have yet come under my obſervation, I have united all the diviſions of M. Daubenton from the claſſes to the ſpecies; becauſe theſe laſt are no more than a hundred in number. See the fourth table.

Serpents form the fifth order of animals in the diviſion of M. Daubenton. The ſcales with which they are covered, and the abſence of feet and fins characterize them very well. They have a head, noſtrils, internal ears, a ſingle ventricle in the heart, the blood almoſt cold, their reſpiration is made at long intervals, and they lay eggs like the oviparous quadrupeds. Serpents have neither neck nor ſhoulders, and the ſcales which cover them are of three kinds. They are either rhomboidal, and cover each other in the manner of tiles, which Linnæus calls ſquammæ; or they are of a long ſquare form, touching without covering each other; Linnæus calls theſe ſcuta: they are only obſervable on ſerpents; when they are very ſmall and of the ſame form they are called ſcutella; or laſtly, they conſiſt of rings encircling the bodies of ſerpents, as is ſeen in the amphyſbena.

Serpents,

Serpents, though without feet, ſometimes move with conſiderable ſwiftneſs, by leaning firſt on their anterior part, raiſing up the middle, and bringing forward the poſterior part of their body; by which means they raiſe themſelves on their tail, and ſpring to ſome diſtance, in order to ſeize their prey. They caſt their ſkin once or twice in the year.

Some ſerpents are venomous; out of 131 ſpecies noted by Linnæus, 23 are dangerous, according to that naturaliſt. All theſe animals, whoſe bite is venomous, have on each ſide of the upper jaw, a tooth much larger than the others, together with a reſervoir filled with a peculiar liquor, which paſſes into the wound through a perforation in the tooth.

It is eſtabliſhed, by the moſt authentic teſtimony, that ſome ſerpents are of a prodigious ſize. Mr. Adamſon, from very exact data, fixes the magnitude of the largeſt ſerpents at 40 or 50 feet in length, and a foot, or a foot and a half in thickneſs. M. Laurenti has paid greater attention than any other naturaliſt to the claſſification of ſerpents. He diſtributes them into ſeventeen genera; but the difficulty of obſerving the diſtinctive characters, has prevented M. Daubenton from adopting his method; this laſt naturaliſt has therefore followed Linnæus in the fifth table. I have inſerted the diviſions and characters of ſerpents from the genera to

127 ſpecies, noted by M. Daubenton. See table the fifth.

CHAP. V.

Of Fiſhes.

ICHTHYOLOGY.

FISHES are animals very different from the foregoing: their interior organs are of a peculiar ſtructure, as we ſhall obſerve in our abridgment of phyſiology. They are diſtinguiſhed from other animals by their having no feet, but fins, by which they move in the water, and by their reſpiring water inſtead of air. It is much more difficult to make obſervations on fiſhes than on other animals, and for that reaſon their natural hiſtory is in a much leſs advanced ſtate.

In order to underſtand the methodical diviſion which we propoſe after Artedi, Linnæus, and Gouan, it will be neceſſary to take a curſory view of the anatomy of their external parts. The bodies of fiſhes may be divided into three parts; namely, the head, the trunk, and the fins.

The head of theſe animals is differently formed. It is either flattened horizontally, or laterally, or elſe round; naked, or co-

vered with ſcales; ſmooth, or covered with aſperites, tubercules, &c. Their mouths are obſerved to have lips either of fleſh or of bone, with appendages, or ſoft and very moveable barbulæ; the teeth fixed either to the jaws, the palate, the tongue, or the throat; the eyes two in number, motionleſs, and without eyelids; the perforations of the noſtrils double on each ſide the opening of the gills or branchiæ; the opercula, or round triangular or ſquare bones deſigned to cloſe the aperture of the branchiæ; the branchial membrane placed beneath the opercula, ſuſtained by ſeveral bones in the form of an arch, whoſe number varies from two to ten. This membrane is folded up beneath the opercula, and muſt be well examined with reſpect to its ſtructure and varieties, becauſe the characters of the genera are moſt commonly taken from the number or form of its radii.

The trunk is of various forms as well as the head; it is either round, globular, long, flat, or angular. The obſerver muſt take notice of the lateral line, which ſeems to divide each ſide of the body into two parts; the thorax placed beneath the gills at the commencement of the trunk, and containing the heart and the branchiæ; the belly, whoſe ribs form the principal ſupports of the fins continued from the head to the tail, and which contains the ſtomach, the inteſtines,

intestines, the liver, the air bladder, the parts of generation; the opening of the anus, which is common to the intestines, the bladder, and the generative parts; lastly, the tail, which terminates the trunk, and is of various forms and magnitudes.

The fins, *pinnæ natatoriæ*, are formed of membranes supported on small radii, some of which are hard, bony, and terminate in a sharp point, which characterizes the fishes called *acanthopterygiani*, so denominated by Artedi; others are flexible, soft, obtuse, and as it were cartilaginous, which characterizes the fishes called *malacopterygiani*. Five sorts of fins are distinguished with respect to their situation; the dorsal, the pectoral, the abdominal, together with those of the anus, and of the tail.

The dorsal fin is impair; it maintains the fish in equilibrium, and varies in situation, number, figure, proportion, &c.

The pectoral fins are situated at the aperture of the gills; they are two in number, and perform the office of arms, and sometimes of wings. They differ as to the place of their insertion, extent, figure, &c.

The abdominal fins are of the greatest importance to be known, because their situation has been assumed by the celebrated Linnæus, as a distinctive character in the classification of fishes. These fins are placed at the inferior part of the body, under the belly, before the

the anus, always lower and nearer to each other than the pectoral fins. They are sometimes wanting; and as Linnæus has compared them to feet, he calls those fishes which are without them *apodes*; but they exist in the greatest number of fishes. Their insertion varies; when they are placed forward or beneath the aperture of the gills, and the pectoral fins, they are called jugular; and the same name is likewise applied to the fishes in which it occupies this place. If they be attached to the thorax behind the opening of the gills, they are then called thoracic; and the fishes which possess this structure are distinguished by the same name in the method of Linnæus. Lastly, when they are placed beneath the belly, nearer the anus than the pectoral fins, they are denoted by the name of abdominal, which term is likewise applied to the fishes distinguished by this structure.

The fin of the anus is impair. It occupies either wholly, or in part, the region situated between the anus and the tail; it differs in form, extent, and number, though it has not been observed double, excepting in the gold fish of China.

The tail fin is placed vertically at the extremity of the body, and terminates the tail. It is the rudder of the fish, or instrument by the various motions of which it changes its direction at pleasure. It like-

wise

wiſe exhibits many varieties in its form, adherence, connection, extent, &c.

After theſe details reſpecting the external anatomy of fiſhes, we ſhall proceed to mention the methodical diviſions of naturaliſts. Before the time of Artedi, no naturaliſt had attempted to arrange fiſhes in a methodical manner; though ſeveral methods were before uſed for the claſſification of other animals. This philoſopher propoſed a ſyſtem of Ichthyology, founded on the nature of the bones of the fins, whether hard or ſoft, pointed or obtuſe, and on the form of the gills. He afterwards attempted to multiply the diviſions by attending to the other parts; but a premature death terminated his labours. Linnæus attempted to eſtabliſh an Ichthyologic method, from the various ſituations of the belly fins; and Mr. Gouan, a celebrated profeſſor at Montpelier, has very ſkilfully combined the two ſyſtems of Artedi and Linnæus. This naturaliſt firſt divides fiſhes into ſuch as have their gills complete; that is to ſay, conſiſting of an aperture and a complete branchial membrane, and thoſe which have their gills imperfect; that is to ſay, wanting either the opercula, or the branchial membrane, or both. The firſt are afterwards diſtinguiſhed from each other by the form of their fins. Theſe parts are in fact compoſed either of hard and ſharp bones, or ſoft, and as it were cartilaginous radii,

radii. Theſe differences conſtitute three claſſes of fiſhes, namely, 1. The acanthopterygiani. 2. The malacopterygiani. 3. The branchioſtegi. In each of theſe claſſes of fiſhes, the belly fins are either wanting, or placed at the neck, thorax, or belly. Mr. Gouan has divided each claſs into four orders; that is to ſay, apodes, jugular, thoracic, and abdominal.

The diſtinctive characters of the genera, which immediately follow theſe diviſions, are founded on the form of the head, of the mouth, of the branchial membrane, and more particularly on the number of radii which ſupport this membrane. See Table VI.

C H A P. VI.

Concerning Inſects.

Entomology.

INSECTS are animals which are known by the form of their body, which is divided as it were into rings, and by two moveable horns which they have on their head, and are diſtinguiſhed by the name of antennæ. Inſects compoſe one of the moſt numerous claſſes of animals, doubtleſs, on account of their minuteneſs; for

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it has been obſerved, the ſmaller theſe creatures are, the more numerous is their production. The hiſtory of theſe animals is highly agreeable and amuſing, and perhaps not the leaſt in point of utility; ſince diſcoveries reſpecting their properties may prove exceeding uſeful in the arts, and in medicine.

The claſſes of inſects exhibit reſemblances with almoſt every other animal, with reſpect to their manners, form, habitations, &c. Some walk like quadrupeds; others fly like birds; others again ſwim, and live in the water like fiſhes; and laſtly, there are others which leap, or crawl along, like certain reptiles. This analogy may even be carried much farther, by a full examination of the ſtructure of their extremities, their mouth, their internal organs, &c.

Inſects externally conſidered, are compoſed of three parts; namely, the head, the thorax, and the abdomen.

The head differs in its form, ſize, and poſition. It is ſometimes very large, and ſometimes very ſmall, with reſpect to the bulk of the inſect. It is either round, ſquare, or long; ſmooth, rough, tuberculated, or tufted with hair. We may obſerve the antennæ placed near the eyes, conſiſting of different articulated and moveable pieces, reſembling a thread terminated either by

a point or a knob. The form of theſe organs muſt be carefully diſtinguiſhed, becauſe this character is almoſt always uſed to diſtinguiſh the genera. 2. The eyes; which are of two ſorts, either in facets, or reſembling net-work, ſmooth and ſmall. Theſe organs are very large in ſome inſects, and in others very ſmall. Their number is various; there are inſects which have only one eye, as the monoculus; others have two, five, or even eight, as for example the ſpider, &c. 3. The mouth; which is formed either of ſtrong and corneous jaws, moveable laterally, or conſiſts of a trunk of various lengths dilated, ſpiral, &c.; or a ſimple, cleft, &c. This part is frequently ornamented with ſmall moveable appendices, called antennulæ, to the number of two or four.

The thorax is the ſtomach of inſects. It is placed between the head and the belly, and is either round, triangular, cylindric, thick, ſlender, &c. It may be conſidered as compoſed of ſix faces, like a cube, which form it ſometimes has. The face, or anterior extremity, is hollowed to receive the head. This articulation is ſometimes made only by a part as ſmall as a thread, as in flies. The poſterior extremity is uſually rounded and articulated with the firſt ring of the abdomen, and is ſometimes joined with this part only by a thread. The ſuperior ſurface is ei-

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ther flat and ſmooth, rounded, prominent, with appendices, or tubercles, or terminated by a kind of border, turned up, which conſtitutes the thorax marginatus. The wings are attached at the poſterior part of this ſurface. Moſt inſects are provided with theſe organs; but as they differ ſingularly from each other, and the principal diviſions of claſſes adopted by methodical writers are founded on theſe differences, it will be neceſſary to attend more particularly to them.

The wings are either two or four in number; among thoſe which have two tranſparent wings, as the fly, the gnat, &c. theſe wings always have beneath the place of their inſertion a ſlender thread terminated by a round button, called balancers, *halteres*, which is covered by a concave membranous ſubſtance. In a great number of inſects theſe two wings are very ſtrong, and folded up under hard, horny, moveable coverings, called ſheaths, or *elytra*. Theſe differ in form; ſome cover the whole abdomen; others are, as it were, cut tranſverſely, and cover only a part; ſome are hard, and others ſoft, and moſt of them towards the top of the ſuture, or line, at which they are applied to each other, have a ſmall triangular piece affixed to the thorax, which is called ſcutellum; but this piece is wanting in ſome. Laſtly, in many inſects the elytra are faſtened together, and are

are formed of one motionleſs piece. The wings are often four in number, and are thin membranes, and tranſparent, as in the libella, the waſp, &c. or they are covered on each ſurface with a coloured powder, which, under the microſcope, appears to conſiſt of ſcales, placed over each other like tiles, *imbricatim*.

The inferior part of the thorax is irregular, conſiſting of ſeveral pieces faſtened to each other; and ſome of the legs are fixed to it. The number of legs varies in inſects; ſome have ſix, and others eight, like ſpiders: others have ten, as the hornet. Laſtly, there are inſects which have a much larger number; the wood-lice have ſixteen; and ſome of ſcolopendra, and centipedes, have as many as ſeventy, and one hundred and twenty, on each ſide. Among thoſe which have no more than ſix, eight, or ten, they are all attached to the thorax, according to Geoffroy; among thoſe which have a larger number, ſome are inſerted in the rings of the belly.

The leg of an inſect is always compoſed of three parts; the thigh, which joins to the body, the leg, and the tarſus. There is often an intermediate piece between the body and the thigh. The tarſus is formed of many pieces, or rings, articulated together, whoſe number varies from two to five. In ſome inſects, the tarſus is more conſider-

able

able in the fore than in the hind feet; a circumſtance which eſtabliſhed an analogy between theſe creatures and many quadrupeds, whoſe fore-feet have a greater number of digits than the hinder. M. Geoffroy has availed himſelf of this character, in his diviſion, as we ſhall hereafter ſee. The tarſus is terminated by two, four, or ſix, ſmall claws, or hooks, and is often furniſhed with bruſhes, or ſpungy balls, on its lower part, by means of which the inſect is capable of walking on the moſt poliſhed ſubſtances, ſuch as glaſs, &c. in any poſition.

On each ſide of the thorax, one or two oblong, oval apertures are obſerved, which are called ſtigmata, through which the inſect reſpires.

The third part of inſects is the abdomen. It is moſt commonly compoſed of corneous rings, or half rings, which ſlip over one another; in ſome the rings are not obſerved, and the abdomen appears to be formed of a ſingle piece: it is uſually larger in males than females. The parts of generation are placed at its extremity; a ſtigma is obſervable on the ſide of each ring, except the two laſt. Many inſects have ſtings at the poſterior part of their abdomen, ſome of which are ſharp and piercing, others in the form of a ſaw, and ſome of that of a gimblet. They ſerve either as inſtruments of defence, or to penetrate

trate ſubſtances in which the inſects depoſit their eggs.

The moſt ſingular phenomenon, in which inſects differ intirely from moſt other animals, conſiſts in the changes of ſtate through which they paſs, or the metamorphoſes they are ſubjected to, before they become perfect inſects. There are ſome inſects, and almoſt all the claſs of aptera, which do not undergo theſe changes, but the greater number are ſubject to them; the inſect does not come out of the egg with the form of the mother, but in that of a worm, with or without feet, the ſtructure of its head and the rings being exceedingly various. This firſt ſtate is the caterpillar; under this kind of maſk, the inſect eats, grows, moves, and changes its ſkin ſeveral times. When it has grown to its full ſize, it changes its ſkin for the laſt time, and no longer appears under the form of a worm, but under a different form, called *nympha chryſalis, aurelia.*

M. Geoffroy diſtinguiſhes four kinds of nymphæ: the firſt is that which does not reſemble an animal; a few rings only are obſerved at the lower part, and the upper part exhibits indiſtinct impreſſions of antennæ, legs and wings. The ſkin of this kind is hard, cartilaginous, and it has only a ſlight motion in its rings. The butterfly, phalæna, &c. are of this kind.

The

The ſecond kind of chryſalis admits of the parts of the perfect animal being diſtinguiſhed beneath a thin and very ſoft ſkin. It is motionleſs, like the foregoing. Inſects with hard coverings to their wings, thoſe with four naked wings, and thoſe with two wings, afford examples of this kind.

The third ſpecies, is that whoſe parts are perfectly developed, and which move; ſuch are thoſe of the gnats and inſects which paſs the two firſt ſtages of their life in the water.

Laſtly, the fourth ſpecies comprehends thoſe which reſemble the perfect inſects in the form of their body, their antennæ, and paws: theſe nymphæ move, and eat; they differ from perfect inſects only in the want of wings, and in their being incapable of procreating. The nymphæ of the libella, of the bug, of graſshoppers, and of crickets, &c. are of this kind.

Inſects, like other animals, were only diſtinguiſhed by the ancient naturaliſts from the places of their habitation. No one before the time of Linnæus attempted to diſpoſe them methodically, according to diſtinguiſhing characters. After Linnæus, to whom we are indebted for the firſt ſyſtematic diviſion of theſe animals, M. Geoffroy attempted to claſs them in a more accurate manner; his diviſion of ſections in genera is a maſterpiece of the kind, for preciſion, accuracy, and

and perſpicuity: we ſhall therefore follow his ſyſtem. M. Fabricius has ſince availed himſelf of the form of the jaws to divide inſects.

M. Geoffroy divides inſects into ſix ſections, according to the abſence, the number, and the ſtructure of the wings: the firſt ſection includes the *coleoptera*, or inſects whoſe wings are covered with caſes. Their mouth, which is armed with two lateral and corneous mandibles, forms likewiſe a general character of this ſection. The May-bug exhibits both theſe characters.

The ſecond ſection comprehends the *hemiptera*, whoſe ſuperior wings are either in a ſmall degree thick and coloured, or rather hard and opake; but as the character of the wings is not ſtrongly marked in this ſection, it is replaced by that of the mouth, which is conſtant. This mouth is a long and ſlender trunk, turned inwards between the feet: the wood-bug and the cicada are of this ſection.

The third ſection is compoſed of *tetraptera*, with farinaceous wings, the four wings being coloured by a ſcaly powder. Theſe have a trunk more or leſs long, and often of a ſpiral form, as in the butterfly: Linnæus calls theſe *lepidoptera*.

In the fourth ſection are placed the *tetraptera*, with bare wings. Their four wings are membranous, and their mandibles

are

are hard: the waſp is of this kind. Linnæus has made two orders of theſe inſects; namely, the *neuroptera*, whoſe anus has no ſting, and whoſe wings have nervous marks; and the *hymenoptera*, which have the anus armed with a ſting, and the wings membranous, without any very apparent nerves.

The fifth ſection contains the *diptera*, or inſects with two wings; their mouth is moſt commonly in the form of a trunk, and they have ballancers under the inſertion of their wings.

Laſtly, in the ſixth and laſt ſection are claſſed, the *aptera*, or inſects without wings, ſuch as the ſpider, the louſe, &c.

Beſides theſe primary diviſions, M. Geoffroy has eſtabliſhed others, to facilitate the diſtinction of inſects. See Table VII.

CHAP.

CHAP. VII.

Of Worms.

WORMS are ſoft animals, of a very different form from inſects, with which they have been confounded by ſeveral naturaliſts, their organization being leſs perfect than that of thoſe animals. They have no bones, properly ſpeaking; and their members are not conſtructed like thoſe of inſects, neither are they, like them, ſubject to paſs through different ſtates. Their organs, deſtined for the purpoſe of generation, are not known; many worms have no head perfectly formed; and laſtly, the abſence of feet and ſcales diſtinguiſh them from all other creatures. The claſs of worms is the moſt numerous, and the leaſt known, of all animals. There are few organic ſubſtances, either living or dead, in which certain worms are not found, that ſubſiſt and are nouriſhed within them. Moſt naturaliſts have placed worms and polypi in the ſame claſs; but it would perhaps be better to ſeparate them, ſince their internal ſtructure and functions perfectly diſtinguiſh them from each other. We know that moſt worms contain a heart,

and

and veſſels, but nothing ſimilar has been diſcovered in polypi. The worms we now ſpeak of muſt not be confounded with the *larvæ* of inſects or caterpillars, which have likewiſe been called worms, merely on account of their form. Their head, furniſhed with mandibles, and their legs, which are more or leſs numerous, conſiſting commonly of ſix, afford characters by which they may be eaſily diſtinguiſhed.

Worms have a conſiderable degree of activity, and in general love moiſture. Some have not a head which can be eaſily diſtinguiſhed; moſt of them are hermaphrodites. Such as have a head, have two moveable horns, which they can retract, and are called *tentacula*. All the worms, of which we are now giving an abridged account, have the property of being re-produced, when cut through; a circumſtance which ſhews, that their organization is ſimple, and reſembles that of polypi.

This claſs of animals may be divided into four ſections: the firſt contains the naked, or bare worms, whoſe organization is beſt known, and which in their leading character reſemble other animals; in the ſecond, we ſhall place worms which have a teſtaceous covering, or ſhell-worms; their organs are leſs known than thoſe of the former ſection; the valuable reſearches of Mr. Adanſon

 prove,

prove, however, that their ſtructure reſembles that of naked worms. The third ſection will contain worms with a cruſtaceous covering; their organization is not ſo well known as that of the foregoing, their external form and the ſtructure of their mouth only having been examined. And laſtly, the fourth ſection will include the polypi. The methodical diviſions of theſe different ſections have already afforded employment to many naturaliſts; Liſter, Linnæus, Klein, Ellis, Pallas, D'Argenville, are thoſe of whoſe aſſiſtance we have availed ourſelves, in the imperfect diviſion exhibited in our eighth table. See Table VIII.

CHAP. VIII.

The Functions of Animals conſidered, from Man to the Polypus.

THE characters peculiar to living and organized bodies, conſiſt, as we have already obſerved, in the different functions executed by means of their organs. We have conſidered thoſe of vegetables; the order we have adopted now leads us to the functions of animals.

That part of the art of medicine, in which the

the functions of animals are examined, is called physiology. This useful and valuable science ought not to be confined to the single consideration of the human species, but should be extended to all animals: in this point of view, we shall cursorily pass over the animal kingdom.

The functions of animals are reducible to the following:

I. Circulation.
II. Secretion.
III. Respiration.
IV. Digestion.
V. Nutrition.
VI. Generation.
VII. Irritability.
VIII. Sensation.

These different functions are observed in man, quadrupeds, cetaceous animals, birds, fishes, oviparous quadrupeds, serpents, and insects. Worms and polypi do not possess them all, neither do serpents nor insects possess them in the same degree.

I. The circulation is one of the most important functions. It is indispensably necessary to maintain life. The organs by which it is performed, are the heart, the arteries, and the veins.

The heart is a conical muscle, towards the apex of which are two cavities, called ventricles; and at its base, two other vessels, called auricles. A large artery, named the

aorta, iſſues from the left ventricle, and diſtributes the blood to the various parts of the body; another artery, of equal magnitude, iſſues from the right ventricle, which is called the pulmonary artery, becauſe it is ſpread into ramifications in the lungs. The right auricle receives the blood which returns from every part of the body, by the two venæ-cavæ; whence the fluid paſſes into the right ventricle: from this laſt it is tranſmitted to the lungs, by the pulmonary artery, and is returned, by the pulmonary veins, into the left auricle, and thence to the left ventricle, from which it is propelled to all the parts of the body through the aorta. This motion, as it takes place in man, conſtitutes two kinds of circulation; that of the whole body, and the pulmonary circulation. The latter was known before the former. Harvey, an Engliſh phyſician, diſcovered the general circulation.

This function is performed in quadrupeds, cetaceous animals, and birds, abſolutely in the ſame manner as in the human ſpecies. In fiſhes, the heart has but one ventricle, and the lungs, or gills, do not receive blood, by means of a peculiar cavity of the heart. Reptiles reſemble fiſhes in this reſpect. The heart of inſects and worms conſiſts of a ſeries of nodules, which contract one after the other; their veſſels are very ſmall, and their blood cold and colourleſs. Polypi have neither heart

heart nor veſſels; and are inferior to vegetables, with reſpect to this function.

II. Secretion is a function, by which different organs ſeparate, from the blood, juices deſtined to particular uſes, as the bile in the liver, &c. This function is one of the moſt general in animals, and is found in all the claſſes; but it is not poſſible to attend to it in each, without entering into too long a detail. It will therefore be ſufficient to obſerve, that in all animals, which have a true circulation, the ſecretions follow the ſame laws as in man; and that it even appears to take place in moſt animals which have not a heart. Beſides the analogy that neceſſarily ſubſiſts between man and animals which have the ſame organs, with reſpect to the functions we are treating of, certain claſſes of animals exhibit peculiar ſecretions, which are not performed in the human ſpecies; ſuch are the muſk and civet in quadrupeds, ſpermaceti among cetaceous animals, the oily fluid, with which birds ſmear their wings, the virulent fluid of the viper, the adheſive fluid of the ſcales of fiſhes, the acrid and acid juices of the bupreſtis, ſtaphylini, ants, and waſps, among inſects; the viſcous mucilage of ſnails, the colouring juices of the purple fiſh or murex, and a great many others, which the natural hiſtory of each animal diſplays.

III. Reſpiration, conſidered in all animals, is a function intended to bring the blood into contact with the fluid they inhabit: men and

quadrupeds, for this purpofe, have an organ called the lungs. This vifcus confifts of a collection of hollow vesicles, which are formed by the expanfion of a membranous and cartilaginous tube, called the arteria trachea, and of blood-veffels, which form a great number of areolæ at the furface of the bronchial veffels: thefe vesicles and veffels are fuftained by a cellular, loofe, and fpungy fubftance, which forms the parenchyma of the lungs. The air diftends the veffels by infpiration; the bafe of the vital air of the atmofphere appears to combine with a principle difengaged from the blood, and forms the cretaceous acid, which is expired, together with the mephitis. The matter of heat, feparated from the vital air, unites with the blood, and reftores thofe properties which it had loft in paffing through the body.

This function is performed in the fame manner in cetaceous animals; excepting, however, that as there is an immediate communication between the auricles, thefe animals are capable of remaining a confiderable time without refpiring.

Though the refpiration in birds be analagous to that of the animals laft treated of, yet it appears to be much more extenfive. Anatomifts have difcovered, in the abdomen of birds, fpungy veficular organs, which communicate with their lungs; and thefe laft extend even into the bones of the wings, which

which are hollow, and without marrow, by a channel placed at the upper parts of the breafts, and which opens in the fuperior part of the os humeri. This happy difcovery of Mr. Camper teaches us, that the air paffes from the lungs of birds into the bones of their wings; and that this fluid, rarefied by the heat of their bodies, renders them very light, and fingularly affifts their flight.*

Fifhes have gills, or branchiæ, inftead of lungs; thefe organs are formed of membranous fringes, difpofed on a bony arch, and charged with a very great quantity of blood-veffels. The water enters by the opening of the mouth of fifhes; paffes through the fringes, which are by that means feparated from each other; preffes and agitates the blood, and paffes out through apertures fituated at the two lateral and pofterior parts of the head, on which two moveable bony valves, called opercula, are placed, and fuftained by the branchial membrane. Duverney fuppofed that the brachiæ feparate the air contained in water. M. Vicq d'Azir, who has paid great attention to the anatomy of fifhes, thinks that the water performs the office of air in the branchiæ of thefe ani-

* This is doubtful. See Mr. John Hunter's account of certain receptacles of air in birds, which communicate with the lungs. Philof. Tranfactions, vol. 74, for the year 1774. T.

mals. It is certain, that as fiſhes do not reſpire air, and convert it into cretaceous acid, their blood does not poſſeſs the degree of heat, which the air gives to ſuch animals as reſpire it.

Inſects have no lungs; they have two tubes, or tracheæ, placed along the back, from which, on each ſide, other ſmaller tubes iſſue forth, and terminate at the lateral part of each wing, by a ſmall cleft, called ſtigma. Theſe ſtigmata appear rather to be deſigned to emit ſome elaſtic fluid, ſince inſects do not quickly die in a vacuum; though they have convulſions, and expire in a few inſtants, if the ſtigmata be covered with oil or varniſh. Worms have an organization ſtill leſs perfect. No kind of reſpiration has been obſerved in polypi, which, with reſpect to this function, are leſs perfect than vegetables, in which we have obſerved the tracheæ.

IV. Digeſtion conſiſts in the ſeparation of the nutritive matter contained in food, and its abſorption, by peculiar veſſels, called chyliferous. It is performed in a channel, which is continued from the mouth to the anus, and which, in man, in enlarged towards the upper part of the abdomen. This enlargement is called the ſtomach. The alimentary canal afterwards becomes narrower, is turned in different directions, and is diſtinguiſhed by the name

of

of the inteſtines. This long tube, which is formed of muſcles and membranes, retains the aliments, ſo as to extract all the nutritive matter they contain. There are likewiſe other glandulous organs, near the ſtomach, whoſe office is to prepare the fluids requiſite to ſtimulate the ſtomach and inteſtines, and to extract the nutritive part of the food: theſe organs are the liver, the ſpleen, and the pancreas. The bile and pancreatic juice flow into the firſt inteſtine, called the duodenum, and mix with the food. Before this mixture is performed, the aliments are diſſolved in the ſtomach, by the gaſtric juice.

The whole courſe of the inteſtines is covered with vaſcular apertures, deſtined to extract the chyle. Theſe veſſels convey it into the receptaculum lumbare, in the thoracic duct, and the chyle is poured into the left ſubclavial vein, in which it mixes with the blood. Such, in a few words, are the mechaniſm and phenomena of digeſtion in man.

Quadrupeds differ greatly in the form of their teeth, ſtomach, and inteſtines: ſome of theſe animals, as the ant-eater, and the ſcaly lizard, which live on ſoft food, have no teeth; others, ſuch as the ſloth and the armadillo, have only grinders; others, as the elephant, and ſea-cow, have molar and canine teeth; laſtly, the greater number have the three kinds of teeth, molar, canine, and inciſive; but their number,

number, poſition, and ſtrength, are ſubject to great variations. The moſt ſtriking circumſtance in this various ſtructure of the teeth, is, that, according to the remark made by Ariſtotle, Galen, &c. there is a conſtant relation between the number and poſition of theſe bones, and the form of the ſtomach. In fact, all quadrupeds, which have inciſive teeth in both jaws, as the horſe, the ape, the ſquirrel, the dog, the cat, have no more than one membranous ventricle, as in man; the anatomiſts call theſe animals *monogaſtrica:* and in theſe the digeſtion is performed abſolutely in the ſame manner as in the human ſpecies. Quadrupeds, which have inciſive teeth only in the inferior jaw, are *polygaſtrica*, and ruminating; ſuch are the camel, the goat, the ram, the ox, the ſtag, &c. Theſe quadrupeds, which are uſually biſule, and armed with horns, have four ſtomachs; the firſt, called in oxen the paunch, is the largeſt, and is divided into four other cavities; it receives the aliments at the ſame time with the ſecond, which opens into the paunch by a large orifice. The herbaceous aliments, contained in theſe organs, dilate, and the air becomes rarefied; the nerves of theſe viſcera are ſtimulated, and an anti-periſtaltic motion is excited, which returns them, through the oeſophagus, into the mouth; where they are again maſticated by the molar teeth, and reduced

duced into a kind of ſoft paſte. In this ſtate, together with the drink, they are conducted, by a new deglutition, into the third ſtomach, called the omaſus, by means of a duct paſſing from the oeſophagus to this laſt ventricle. Laſtly, they paſs from the omaſus into the fourth ſtomach, where they are truly digeſted. The inteſtines of ruminating animals, are likewiſe much more extended than thoſe of monogaſtric quadrupeds. Cetaceous animals perfectly reſemble theſe laſt, in the mechaniſm of the now treated of function. Birds differ from each other in the ſtructure of their ſtomach; in ſome it is membranous, and in others fleſhy, or muſcular. The firſt ſort, which may be called *hymenogaſtrica*, are carnivorous; all birds of prey are of this ſpecies. Their ſtomach contains a very active juice, capable of ſoftening bones, according to the experiments of Reaumur: their bile is likewiſe very acrid. The ſecond, which may be called *miogaſtrica*, ſubſiſt only on grain; their ſtomach is formed of a quadrigaſtric muſcle, armed with a hard and thick membrane, proper for trituration: theſe birds have likewiſe a double cœcum.

Fiſhes have a membranous long ſtomach, with many appendices; their inteſtines are in general ſhort. Reptiles exhibit the ſame ſtructure; their ſtomachs are capable of an aſtoniſhing degree of diſtenſion. Serpents are often ſeen to ſwallow intire animals, much larger than themſelves.

Insects have a stomach, and intestines, which are well organized. Swammerdam and Perrault affirm, that the mole cricket has four stomachs. Their stomachs are divided into four cavities, as may be easily seen by dissecting this insect, which is very common, and much feared by gardeners. Worms have a very irregular stomach, and likewise small intestines. The polypus seems to be merely a stomach, for it digests very quickly: the same aperture serves this creature both as mouth and anus.

V. Nutrition is a consequence of digestion and circulation. As the solids always lose, or become diminished, by the motions they perform, and require to be repaired, this is performed by nutrition. In the early part of life, they increase in bulk, and the animal grows. The cellular membrane is usually considered as the organ of this function, and the lymph as the fluid proper to restore the solids. It appears, nevertheless, that each organ is nourished by a peculiar and proper matter, which it separates, either from the blood, the lymph, or some other fluid which passes through it. For example; the muscles are maintained by the fibrous matter, which they separate from the blood; the bones extract calcareous phosphoric salt, and lymphatic matter; the pure lymph dries in laminæ on the cellular texture; the con-

cressible

creſſible oil being at the ſame time depoſited. Each organ, therefore, is nouriſhed in a peculiar manner, and in each, nutrition is a true ſecretion. Quadrupeds and cetaceous animals perfectly reſemble man, with regard to this function. The ſame remark applies alſo to birds: but it is performed much leſs quickly with fiſhes; for which reaſon theſe animals live a very long time: the age of ſome of them is not known; but in general, the ſlower the nutrition and the growth, the longer the life.

Inſects exhibit nothing remarkable with regard to this function. It muſt only be obſerved, that they grow only in the form of larvæ, and not in that of the chryſalis, or of the perfect inſect. Swammerdam and Malpighi have proved, that the larva contains a perfect inſect, ready formed beneath a number of ſkins. The caterpillar likewiſe contains the butterfly, whoſe wings and feet are doubled up.

In worms and polypi, nutrition is performed in the cellular membrane, and is likewiſe performed in vegetables, by means of the reticular and veſicular membranes.

VI. Generation, conſidered in all animals, is performed in many different manners; moſt of them have different ſexes, and require conjunction. Such are the human ſpecies, quadrupeds, and cetaceous animals. The females of quadrupeds have a matrix,

ſeparated

ſeparated into two cavities, *uterus bicornis*, and a conſiderable number of teats; they have not the menſtrual flux; moſt of them bear ſeveral young at a time; the time of their geſtation is ſhorter; ſeveral have a peculiar membrane to receive the urine of the fœtus; this membrane is called allantoides.

The generation of birds is very different. The males have a very ſtrong and imperforated genital organ, which is often double. The vulva, in females, is placed behind the anus; the ovaria have no matrices; and there is a duct, for the purpoſe of conveying the egg from the ovarium into the inteſtines; this paſſage has been called *oviductus*. The egg of pullets has exhibited unexpected facts to phyſiologiſts, who have examined the phenomena of incubation. The moſt important diſcoveries are thoſe of Malpighi and Haller. The latter found the chicken, perfectly formed, in eggs which were not fecundated.

There is no determinate conjunction among fiſhes; the female depoſits its eggs on the ſand, over which the male paſſes, and emits its ſeminal fluid, doubtleſs for the purpoſe of fecundating them; theſe eggs are hatched after a certain time.

The males of ſeveral oviparous quadrupeds have a double, or forked organ. Among ſerpents, the viper is not viviparous.

Inſects alone, exhibit all the varieties which

which are obſerved in other animals. There are ſome, and indeed the greater number, which have the ſexes in two ſeparate individuals; among others, the re-production is made either with or without conjunction, as in the vine-fretter, Puceron; one of theſe inſects, confined alone beneath a glaſs, produces a great number of others. Mr. Bonnet has eſtabliſhed this fact, by experiments very carefully repeated. The organ of the male is incloſed in the abdomen, and may be cauſed to appear, by lightly preſſing the extremity of this part. It is uſually armed with two hooks, to ſeize the female. The place of theſe organs is greatly varied; with ſome it is at the upper part of the belly, near the breaſt-plate, as in the female of the dragon-fly; in others, it is at the extremity of the antenna, as in the male ſpider. Inſects multiply prodigiouſly, and are almoſt oviparous, except the wood-louſe.

Worms are hermaphrodites; each individual has two ſexes, and the conjunction is double, as is obſerved in the earth-worm and the ſnail.

Mr. Adanſon adds, that bivalves, ſhell animals, or concha, have no organs of generation, and reproduce their young without conjunction; theſe worms are viviparous. Univalves, or ſnails, are oviparous; the ſmall animals, whether they iſſue from the belly

of

of the mother, or from eggs, have their ſhell ready formed.

Polypi are the ſingular animals, with reſpect to generation; they are reproduced by buds, or offsets: a bud is ſeparated from each vigorous polypus, which is fixed to ſome neighbouring body, and grows: polypi are likewiſe found on their ſurface, in the ſame manner as branches iſſue from the trunks of trees.

The mere phenomena of generation compoſe the whole of our knowledge of the ſubject; and all the ſyſtems invented to explain this myſtery are attended with inſurmountable difficulties: they may be ſeen collected in the Phyſiology of Haller, the Venus Phyſique of Maupertuis, and the Natural Hiſtory of Buffon. Mr. Bonnet has treated largely on this ſubject, in his conſiderations on organized bodies. M. De Buffon has given an ingenious ſyſtem, which may be ſeen in his work.

VII. Irritability is the property which certain organs, called muſcles, poſſeſs of contracting or ſhortening, by the action of any ſtimulus which touches them. Mr. Haller has proved this valuable doctrine in the moſt perſpicuous manner. The muſcles of man, of quadrupeds, of cetaceous animals, and of birds, reſemble each other; they are all alike red, compoſed of fibres, united in bundles of different forms, covered with ſilver-coloured

loured membranes, called aponeurofes, and terminated by flat, or round cords, named tendons.

The mufcles of fifhes are white, and much more irritable than thofe which are red. The irritability in oviparous quadrupeds and ferpents is ftill ftronger, and lafts a long time after the death of the animal. This appears to be a common property in all animals whofe blood is cold; whereas, in animals which have warm blood, it difappears in proportion as that fluid cools.

Infects have their mufcles placed within their bones, which are hollow, and of the nature of horn. This ftructure may be well obferved in the hollow thigh of the large green grafshopper, and may likewife be eafily obferved in the lobfter.

The mufcles of worms are very pale, and irritable; they are likewife very ftrong in covered worms, which have a heavy fhell to carry.

Polypi are very irritable; they contract into a fingle point, and move their arms with fingular agility; yet their ftructure does not appear to be mufcular.

It is from the property of irritability that animals poffefs the power of tranfporting themfelves from place to place, and of performing a great number of motions, to remove noxious things, and to obtain thofe which are ufeful. The hiftory of this func-

tion ought, therefore, to include that of animal motions. Standing, walking, leaping, flying, creeping, or ſwimming, are combined actions, or the reſults of muſcular contractions, in each claſs of animals. An explanation of theſe, would require a deſcription of the extenſor muſcles of the thigh of man, for ſtanding; that of the extremities of the figure of the body; the long and acute face, and the thorax, laterally compreſſed, in quadrupeds, for leaping; of the ſtructure of the feathers, the ſternum, the pectoral muſcles, the beak, the tail, and the interior texture of the bones, of birds, for flying. In this hiſtory, likewiſe, it would be neceſſary to conſider at large, the muſcular annuli, the ſcales, or the tubercules, which anſwer the purpoſe of feet in reptiles; the form of the body, the ſtructure of the fins, of the air-bladder, and its communication with the ſtomach, in fiſhes; and in inſects, the ſtructure, number, and poſition of the feet, the appendices of the tarſus, the form, poſition, and nature of the wings, the ballancers, &c. But it is ſufficient, in this place, to have ſhewn the importance of theſe conſiderations, and ſuch as peculiarly deſerve the attention of the phyſiologiſt.

Laſtly, there is another conſideration, which does not appear to have been ſufficiently attended to; namely, that a muſcle may be regarded as a ſecretory organ, appropriated

priated to the ſeparation of the fibrous and irritable matter, of which we ſhall elſewhere ſpeak; and that the imperfections of this kind of ſecretion ought to be very carefully obſerved by phyſicians. We ſhall reſume this ſubject in our examination of the blood.

VIII. Senſibility is a function, by means of which animals experience the ſenſations of pleaſure and pain, according to the nature of the bodies which are in contact with their organs. The ſenſes depend on the brain, the medulla allongata, the ſpinal marrow, and the pairs of nerves, which iſſue in great numbers from theſe three foci; without theſe organs, ſenſibility could not exiſt. In order to underſtand the mechaniſm of this function more readily, we may divide into three regions, thoſe organs which are continued, and ſeem to form but one, which phyſiologiſts have called the ſenſible man: theſe three regions conſiſt of the brain, the cerebellum, and the medulla allongata; the middle or part of communication conſiſts of the nervous fibres, and the ſenſitive expanſion, or dilated extremity, of the nerves. This extremity exhibits various forms in different organs; in ſome it is membranous and reticular, as in the ſtomach and inteſtines; in others, it is ſoft and pulpy, as at the bottom of the eye, and in the labyrinth of the internal ear: in ſome ſituations, it has the form of papillæ, as beneath the ſkin, on the

tongue, and on the glands, &c. and in others it is ſpread into long, ſoft, and flat fibres, as in the naſal membrane of Schneider.

The brain in man is larger and better organized than in other animals, and is the cauſe of his underſtanding. In quadrupeds it is much ſmaller; but on the other hand, their nerves are more ſenſible, and their ſenſes more acute, eſpecially that of ſmell, the organ of which is much dilated, and as it were multiplied, by the number of ethmoidal laminæ. Their thick hairy ſkin deprives them, in a great meaſure, of the ſenſe of touch; but their taſte is very acute. The ear has the ſame apparatus, as in man.

Cetaceous fiſh have ſcarcely any brain, in proportion to the maſs of their bodies; this organ is ſurrounded with an oily and thick fluid; their ſenſes are obtuſe.

The brain of birds has neither the ſame ſtructure nor the ſame apparatus of folds, eminences, and concavities, as that of man and quadrupeds. The beautiful ſtructure of the eyes of theſe animals, their magnitude, the thick and cartilaginous ſclerotica, the internal eye-lid, or *membrana nictitans*, moved by peculiar muſcles, the maſs of the cryſtalline and vitreous humours, the veſſel of black matter contained at the extremity of the optic nerve, the brilliant colour of the choroides, all denote a complicated organization, and a peculiar care taken by nature

to

to render the ſight of birds penetrating; that they may ſee their prey at a great diſtance, and avoid the dangers which the rapidity of their flight would otherwiſe have continually led them into; and, in a word, to promote that agility and quickneſs of motion, which appear to be the lot of theſe animals. Their ſmell is leſs perfect than their ſight; they do not appear to be very ſenſible of the ſmell and taſte of food; the ſituation of the apertures of the noſtrils, and the hard membrane which covers the beak, ſerve to explain theſe phenomena with ſufficient facility.

Among reptiles the ſenſibility is not very conſiderable. The brain is very ſmall, and the nerves have no ganglions; the ſenſes, in general, do not appear to be active, though the eye, and internal ear, preſented a very beautiful organization to Meſſrs. Klein, Geoffroy, and Vicq d'Azyr.

Fiſhes have a very ſmall brain, and their cranium is filled with an oily matter. Their ſenſes, more eſpecially their ſight and hearing, are of conſiderable delicacy. The organ for the latter of theſe ſenſes is very well formed, as Meſſrs. Klein, Geoffroy, Camper, and Vicq d'Azyr have obſerved. Such naturaliſts as have ſuppoſed fiſhes to be deaf, appear therefore to be miſtaken.

Inſects have no brain, but a lengthened medullary ſubſtance, of a cylindric form,

full of nodules, which occupies the whole length of their body. From this ſubſtance iſſue nervous fibres, which accompany the diviſion of the trachea. The eyes of inſects are known. Swammerdam has deſcribed an optic nerve, which is divided in ſuch eyes as have the appearance of network, into as many fibres as there are facets in that membrane. It is not known whether they have an organ of hearing.

Few or no traces of the ſenſible organ are perceived in worms. Swammerdam found in the ſnail a brain moveable and with two lobes, eyes placed either on the baſe or at the point of the tentacula, and an optic nerve, contractable like thoſe kind of horns. Mr. Adanſon affirms, that eyes are ſometimes either wanting in worms, or that they are covered with an opake ſkin.

As to polypi, they have no organ of ſenſe, though they appear to ſeek the light.

Senſibility is therefore a function enjoyed by man in a much ſtronger degree than by other animals. It is this which diſtinguiſhes him, and places him at the head of the animated creation; and this function requires to be carefully and minutely inquired into, by the legiſlator, the philoſopher, and the phyſician.

CHAP.

CHAP. IX.

Concerning the Chemical Analyſis of Animal Subſtances in general.

THE analyſis of animal ſubſtances is a part of chemiſtry, which is the moſt difficult, and leaſt advanced cf any. The ancient chemiſts contented themſelves with diſtilling theſe ſubſtançes by a naked fire; an operation which is now known to alter, and intirely change bodies of ſo compounded a nature as the ſolids and fluids of animals. Some of the fluids of the human frame, and of certain quadrupeds, only have been ſubjected to this analyſis.

Many cauſes oppoſe the advancement of this branch of chemiſtry; the difficulty and unpleaſantneſs of theſe experiments, the ſmall number of expedients for the treatment of animal matters, without changing them very much, the impoſſibility of finding the moſt remote ſynthetical method of reproducing theſe matters, and more particularly the unintereſting nature of theſe reſearches to chemiſts who are not phyſicians, are the principal motives which have hitherto impeded the progreſs of ſcience reſpecting them.

them. Neverthelefs, the refearches of certain modern philofophers, efpecially Meffrs. Rouelle, Macquer, Bucquet, Poulletier de la Salle, Berthollet, Prouft, Scheele, and Bergman, have opened a new path, and fhew that the art of healing may receive the greateft advantages from inquiries of this nature.

The bodies of the principal animals, fuch as man and quadrupeds, to which our attention is particularly directed, are formed of fluids and folids. The fluids of animals are diftinguifhed into three claffes, relative to their ufes. The firft clafs contains the recrementitial humours, defigned to nourifh and fupport certain organs. The fecond comprehends the excrementitial humours which are excluded out of the body, by certain emunctories, as ufelefs, and capable of producing noxious effects, if retained too long. In the third are ranked, fuch as are of the nature of the two preceding, being partly recrementitial, and partly excrementitial: the former are the blood, the lymph, the jelly, the fibrous or glutinous part, the fat, the marrow, the matter of internal perfpiration, and the offeous juice; the latter comprehends the fluid of infenfible tranfpiration, the fweat, the mucus of the noftrils, the cerumen of the ears, the gummy matter of the eyes, the urine, and the fæces. Thefe laft are the faliva, the tears, the bile, the pancreatic juice, the gaftric and inteftinal

tinal juices, milk, and the ſeminal liquor. We cannot examine all theſe fluids in the order we have enumerated them; 1. Becauſe they are very little known; 2. Becauſe it is indiſpenſably neceſſary to treat of thoſe, in the firſt place, whoſe analyſis is the moſt advanced.

The ſolids of animals, which form the parenchyma of their different organs, may be divided into three claſſes; the firſt containing ſoft and white parts, as the laminæ of the cellular tiſſue, the membranes, the membranous viſcera, the aponeuroſes, the ligaments, the tendons, and the ſkin. The ſoft and red parts form a ſecond claſs, very diſtinct from the firſt; ſuch, in particular, are the muſcles, and a part of thoſe organs which contain muſcular fibres, ſuch as the ſtomach, the inteſtines, the bladder, the matrix, &c. Laſtly, the third claſs comprehends the bony ſolids.

The animal analyſis is at preſent very different from that formerly uſed. The decompoſition by fire is now no longer practiſed, and animal matters are treated with re-agents, more eſpecially acids, alkalis, ſpirits of wine, &c. The different fluids, mixed with each other, or contained in the veſicles of the different parts, are ſeparated by repoſe, by decantation, by filtration, or by expreſſion. The action of theſe ſubſtances on colouring matters is examined, as well as the ſeveral

ſeveral changes they undergo at different temperatures. By careful evaporation of animal liquors, the different ſalts they contain are ſeparated without alteration.

By theſe methods of analyſis, modern chemiſts have made many important diſcoveries. Scheele has diſcovered ſeveral acids different from all thoſe before known. M. Berthollet has aſcertained the exiſtence of diſengaged phoſphoric acid in urine, and in ſweat; he has likewiſe found a very conſiderable quantity of mephitis in animal matters. This laſt diſcovery is one of the moſt important parts of the animal analyſis; the preſence of mephitis, in theſe ſubſtances, and eſpecially in the fibrous parts, explains the difference which exiſts between them and vegetable matters. To obtain this elaſtic fluid, muſcular fleſh muſt be treated with the nitrous acid; a conſiderable quantity is diſengaged, even without the aſſiſtance of external heat. This mephitis paſſes before the nitrous air, and the receiving veſſels muſt be changed as ſoon as the latter begins to appear.

By this diſcovery, M. Berthollet explains the formation of volatile alkali, afforded by animal ſubſtances, ſubjected to the action of fire, and alſo the production and diſengagement of this ſalt by putrefaction; together with the relation or reſemblance of theſe ſubſtances with vegetable matters, which putrefy,

putrefy, and afford volatile alkali by diſtillation. It appears, in fact, that this alkali is formed, in both caſes, by the combination of inflammable gas with mephitis. I cannot do better than quote, in this place, the words of M. Berthollet on the general nature of animal ſubſtances, in a memoir read at a public meeting of the Faculty of Medicine, and inſerted in the Journal de Phyſique, Vol. XXVIII. Page 272.

"Organized bodies are principally com-
" poſed of two ſubſtances, which have very
" evident diſtinctive characters: the one
" affords acid, when decompoſed by the
" action of fire, and the other volatile al-
" kali; the one forms ardent ſpirit, by fer-
" mentation, the other putrefies immedi-
" ately, and affords volatile alkali; the one,
" by calcination, affords a coal, which burns
" readily, the other is reduced into a coal
" of difficult combuſtion: laſtly, the for-
" mer compoſe the greateſt part of vege-
" table, and the latter of animal, ſubſtances;
" whence they are diſtinguiſhed by the two
" denominations.

"M. Bergman formed, by means of ſugar
" and the nitrous acid, an acid which he
" called the ſaccharine acid, and which
" poſſeſſes remarkable properties. I applied
" this kind of analyſis by the nitrous acid
" to animal ſubſtances, and I found that
" they all afforded a greater or leſs quantity
" of

" of saccharine acid, but always accompa-
" nied with a peculiar oil. I observed that
" no ammoniacal salt was obtained, but
" that a residue was afforded, which is not
" found in vegetables. From these first
" experiments I concluded (Memoires de
" l'Academie, 1780) that animal substances
" contained a substance analogous to sugar,
" united to an oil, which I considered as
" peculiar to animal substances. My ex-
" periments likewise informed me, that the
" volatile alkali did not exist in animal sub-
" stances, but that it arose from a combi-
" nation formed either by the action of heat,
" or the influence of putrefaction; and
" lastly, the residue concerning which I
" did not explain myself in that memoir,
" contains phosphoric acid in excess, com-
" bined with calcareous earth.

" I afterwards examined the action of
" lime and metallic salts on animal sub-
" stances, and proved, that this action in
" which their causticity consists, is a con-
" sequence of the chemical affinities of the
" metallic calces, which tend with various
" degrees of force to become revived; so
" that those which are very easily revived,
" such as the calces of silver and of mer-
" cury, have a strong degree of causticity,
" and form very caustic salts. Hence
" it follows, by applying the modern dis-
" coveries of philosophers to the theory I
" have

" have given, that it is the air combined in
" metallic calces, and deprived of the prin-
" ciple of elaſticity, which tends to unite
" with a principle of animal ſubſtances,
" and this principle appears to me to be
" the oil they contain; but the cauſticity
" of alkalis cannot be attributed to the ſame
" cauſe, but muſt be the effect of another
" affinity. I have proved in the Memoirs
" of the Academy for the year 1782, that
" the cauſtic alkali diſſolved animal ſub-
" ſtances without diſuniting their princi-
" ples. I have ſhewn the properties of
" this combination, and have availed myſelf
" of it to unite the animal ſubſtances with
" different metallic calces; ſeveral combi-
" nations were produced, which were be-
" fore unknown to chemiſts; but the cauſ-
" tic alkali treated in the ſame manner with
" vegetable ſubſtances formed no combina-
" tion."

" By purſuing my inquiries, I have ſuc-
" ceeded in determining the principles of
" the volatile alkali. I have ſhewn, that
" the volatile alkali is a combination of
" detonating inflammable gas, or, to ſpeak
" more accurately, of the inflammable gas
" of water and phlogiſticated air, or me-
" phitis: ſo that the inflammable gas forms
" nearly the ſixth part of the weight, or
" two-thirds of the volume of the volatile
" alkali. I have ſince determined how the
" volatile

" volatile alkali is produceable by putrefac-
" tion, or by the action of fire. All mat-
" ters which have the character of animal
" ſubſtances contain mephitis, which may
" be abundantly ſeparated by means of the
" nitrous acid. It muſt neceſſarily happen,
" therefore, when theſe ſubſtances are diſ-
" tilled, that their mephitis muſt paſs into
" ſome combination, or that it will be found
" among the aeriform products; but it is
" not found in theſe laſt, as I have aſcer-
" tained, by detonating the inſtammable gas
" obtained by this method in the eudiometer
" of M. Volta, and comparing it with the
" inflammable gas obtained by the diſtilla-
" tion of charcoal, and that of vegetable
" ſubſtances; and there is nothing among
" the other products of the diſtillation but
" the volatile alkali, which can have re-
" ceived it into its compoſition. Conſe-
" quently, whenever volatile alkali is form-
" ed, the mephitis of the animal ſubſtances
" combines with the inflammable gas, which
" is ſeparated from the oil, or moſt proba-
" bly with that which ariſes from the de-
" compoſition of the water, whoſe vital air
" at the ſame time combines with the char-
" coal to form fixed air. In putrefaction,
" the inflammable gas combines with the
" mephitis; whereas in the ſpirituous fer-
" mentation, the ſame gas combines with
" a vegetable oil and ſugar, to form ſpirit
" of

" of wine, in which I have found and ſepa-" rated theſe ſubſtances, by means of the " dephlogiſticated marine acid.

" From theſe ſeveral obſervations it fol-" lows, that animal ſubſtances are much " more compounded than ſubſtances which " are purely vegetable. They contain a " matter analogous to ſugar, a peculiar oil, " phoſphoric acid combined with a ſmall " quantity of calcareous earth, mephitis, " and very probably fixed air. It is the " phoſphoric acid which exiſts in the coal " of animal ſubſtances, combined with a " portion of the true charcoal, of the oil, " and with earth, that appears to me to " conſtitute the difference obſerved to exiſt " between the coals of animal ſubſtances " and thoſe of vegetables."

Such is the clear and perſpicuous manner in which M. Berthollet conceives and explains the general nature of animal ſubſtances. When theſe accurate reſults are compared with the vague notions hitherto exhibited reſpecting the difference between vegetable and animal matters, we are aſtoniſhed at the progreſs which chemiſtry has made of late years, by the reſearches of the Swediſh and French chemiſts. There is every reaſon to think, that a connected ſeries of inquiries into the nature of animal matters, according to the plan ſketched out by the moſt celebrated chemiſts from the time of Mar-

graaf

graaf and Rouelle to the preſent, would afford many valuable particulars of information reſpecting their formation, alterations, and deſtruction; and would be more particularly uſeful in the art of medicine. The application of the diſcoveries already made, which we ſhall exhibit in the following chapters, will place this aſſertion beyond all doubt.

CHAP. X.

Concerning the Blood.

THE blood is the moſt important, the moſt compounded, and the moſt impenetrable of the recrementitious humours. We ſhall treat of it in the firſt place, becauſe, according to the doctrine of the greateſt phyſicians, it is the ſource and focus of all the other animal fluids. Many phyſicians, and particularly Mr. Bordeu, conſidered it as a kind of fluid fleſh, and as a compound of all the animal humours. This opinion is not intirely proved, though it is very probable.

The blood is a fluid of a beautiful red colour, and an unctuous fat conſiſtence, as it were ſaponaceous, of an inſipid and rather

ſaline taſte, which is contained in the heart, the arteries, and the veins. This fluid differs greatly, according to the regions through which it paſſes; it is not, for example, the ſame in the arteries, and in the veins, in the ſtomach, and in the region of the liver, in the muſcles, and in the glands, &c. This fact has not been ſufficiently attended to by chemiſts.

When we conſider the blood, with reſpect to the whole animal kingdom, we may obſerve that it varies remarkably in different animals, with reſpect to colour, conſiſtence, ſmell, and more eſpecially temperature. This laſt property is the moſt important, and appears to depend on the circulation and the reſpiration. The blood of men, quadrupeds, and birds, is hotter than that of the medium they inhabit; they are therefore called animals with warm blood. In fiſhes and reptiles it is nearly of the temperature of the medium they inhabit; for which reaſon they are called animals with cold blood. It is probable, that differences equally conſiderable would be found to obtain in all the other properties of this fluid, and eſpecially the chemical qualities or characters, if the blood of all animals were properly examined.

The blood of man, to which our attention is particularly directed, differs according to the age, ſex, temperament, and ſtate of

health of the individual: in infancy, in the female ſex, and in conſumptive perſons it is paler, and thinner; in robuſt and healthy men it is thicker, of a deeper colour, almoſt black, and of a much more ſaline taſte.

Before we proceed to the analyſis of blood, it will be proper to ſpeak of its phyſical properties; namely its colour, temperature, taſte, ſmell, and peculiar conſiſtence, which we have already mentioned. The microſcope diſcovers a great number of globules, which, when broken, according to Leuwenhoek and Boerhaave, by paſſing through the ſmaller paſſages, loſe their red colour, become yellow, and afterwards white; ſo that, according to the phyſician of Leyden, a red globule is an aſſemblage of many ſmaller white globules, and owes its colour to its aggregation only. The blood likewiſe preſents remarkable phyſical properties: while hot, and in motion, it remains conſtantly fluid and red; when it cools at reſt it takes the form of a ſolid maſs, which gradually and ſpontaneouſly ſeparates into two parts; the one red, which floats above, whoſe colour becomes deeper, and which remains concrete, till it is altered by putrefaction; the other, which occupies the lower part of the veſſel, is of a yellow greeniſh colour, and adheſive: it is called ſerum or lymph. This coagulation and ſpontaneous ſeparation

ſeparation of the two parts of the blood takes place at the laſt moments of the life of the animal, and produces thoſe concrete ſubſtances which are found in the heart and the large veſſels, and have been falſly taken for polypi. Blood expoſed to a gentle heat long continued, undergoes the putrid fermentation. By diſtillation on the water-bath, it affords phlegm of a faint ſmell, which is neither acid nor alkaline, but readily putrefies by virtue of an animal ſubſtance it holds in ſolution. Blood heated more ſtrongly, coagulates, and gradually dries, as De Haen has diſcovered, loſing ſeven-eighths of its weight, and effervеſcing with acids. By a well managed fire, it hardens into a kind of corneous ſubſtance. If dried blood be expoſed to the air, it ſlightly attracts humidity, and at the end of ſome months a ſaline efflореſcence is formed, which Rouelle found to be ſalt of ſoda. By diſtillation with a naked fire, it affords an alkaline and partly acid phlegm; that is to ſay, in the ſtate of ſal-ammoniac, ſuper-ſaturated with alkali. The nature of this empyreumatic acid, firſt perceived by Wieuſſens, and which has excited ſuch diſputes among phyſiologiſts, has not yet been properly examined. A light oil afterwards comes over; next a coloured and ponderous oil, and concrete volatile alkali, or ammoniacal chalk, contaminated by the thick oil; a ſpungy coal remains in the

 retort,

retort, which is very difficult to incinerate, and contains ſea ſalt, cretaceous ſoda, iron, and a ſubſtance apparently earthy, which is found to be calcareous phoſphate.

Blood united to alkalis becomes more fluid by ſtanding. Acids immediately coagulate it, and change its colour. By filtration, and evaporating of the filtrated liquor to dryneſs by a gentle fire, and ſubſequent lixiviation of this reſidual matter, ſuch neutral ſalts are obtained, as ſalt of ſoda forms with each acid; any of which may be indiſcriminately uſed. Spirit of wine coagulates blood.

Experiments made on blood in its original ſtate, do not ſhew the nature of the ſubſtances which compoſe this fluid; but the ſpontaneous decompoſition of blood, and the ſeparation of its two parts, the clot and the ſerum, afford a method of performing this by examining each ſubſtance in particular. Till within a few years, the chemical analyſis of blood was confined to what has been related in the foregoing pages. Meſſrs. Menghini, Rouelle the younger, and Bucquet, have examined this fluid in a very different manner. They have made experiments with this ſubſtance, which ſhew how nearly the analyſis of animal matters is capable of being brought to perfection by following their ſteps. From the reſearches of theſe learned men, we ſhall proceed to conſider

ſider the properties of each of the ſubſtances which compoſe blood.

The ſerum, far from being pure water, is a peculiar matter of great importance to be conſidered, and to which we give the name of the albuminous fluid. It is of a yellowiſh white, inclining to green; its taſte is dull and ſaline; its conſiſtence unctuous and adheſive. When expoſed to heat, it coagulates and hardens long before it boils. It converts ſyrup of violets to a green. When diſtilled on the water-bath, it affords a mild and inſipid phlegm, neither acid nor alkaline, but ſubject to putrefaction: the matter in the retort is then dry, hard, and tranſparent like horn, and no longer ſoluble in water; but by a ſtrong heat it affords an alkaline phlegm, much concrete volatile alkali, and a very fetid oil. All theſe products in general have a peculiar fetid ſmell. The coal of ſerum diſtilled by a naked fire, almoſt intirely fills the retort. It is ſo difficult to incinerate, that it requires to be kept red hot for ſeveral hours, with a large ſurface expoſed to the air, before it can be reduced to aſhes. The aſhes are of a blackiſh grey, and contain marine ſalt, chalk of ſoda, and calcareous phoſphate.

Serum expoſed for a certain time to a warm temperature in an open veſſel, paſſes quickly to putrefaction, and then affords much concrete volatile alkali of an abomi-

 nable

nable ſmell. It putrefies ſo rapidly, that Bucquet could not decide whether it paſſes to acidity before it becomes alkaline. This fluid unites with water in all proportions, and then loſes its conſiſtence, its taſte, and its greeniſh colour; the mixture muſt be agitated, in order to promote the union of the two fluids, which are kept apart by their different denſities. Serum poured into boiling water, for the moſt part coagulates inſtantly. A portion of this fluid forms with water a kind of white, opake, and milky fluid, which, according to Bucquet, has all the characters of milk; that is to ſay, it affords cream, coagulates by heat, by acids, &c.

Alkalis added to ſerum, render it more fluid by a kind of ſolution. Acids change it in an oppoſite manner, by giving it conſiſtence, and by coagulating it. This laſt mixture being filtrated, and the fluid evaporated, the neutral ſalt which the acid made uſe of forms with ſoda, is obtained; which proves, that this laſt ſalt exiſted in a diſengaged ſtate, and poſſeſſed of all its properties, in the ſerum. The coagulation formed in this liquor by the addition of an acid, diſſolves very quickly in volatile alkali, which is the true ſolvent of the albuminous part; but it is not all ſoluble in pure water. Acids precipitate this ſubſtance united to the volatile alkali. The coagulation diſtilled by

by a naked fire affords the ſame products as dried ſerum, and its coal contains much cretaceous ſoda; which proves, according to Bucquet, that there is a portion of this ſalt ſo intimately combined in the ſerum, as not to be ſaturated by the coagulating acid.

The ſerum, in its denſe ſtate, affords mephitis by the action of the nitrous acid on the application of a gentle heat. If the heat be raiſed, nitrous gas is diſengaged from the mixture; the reſidue affords the acid of ſugar, and likewiſe a ſmall quantity of the peculiar acid, called maluſian acid, by M. de Morveau. (See the Preliminary Diſſertation at the commencement of our firſt volume, page lxxxviii).

Serum does not decompoſe the calcareous and argillaceous neutral ſalts; but it decompoſes metallic ſalts very readily, It is coagulable by ſpirit of wine, and this coagulation differs greatly from that which is formed by acids, more particularly in its ſolubility in water, as Bucquet has diſcovered. This liquid therefore appears, from theſe experiments, to be an animal mucilage compoſed of water, acidifiable oily baſes, marine ſalt, chalk of ſoda, and calcareous phoſphate; this laſt appears to produce the roſe-coloured precipitate, which I have obtained by pouring the nitrous ſolution of mercury into ſerum. Though the liquid be ſcarcely coloured, the

the addition of nitrous acid, and more eſpecially of mercurial nitre, produces a roſe or light fleſh colour, which I have frequently obſerved in many other animal liquors. The moſt ſingular property of this mucilage, which deſerves the attention of phyſicians is, its becoming concrete by the action of fire, and of acids. Mr. Scheele thinks that this phenomenon ariſes from the combination of heat.

The clot of blood expoſed to the heat of a water-bath, affords an inſipid water, and becomes dry and brittle. By diſtillation it affords an alkaline phlegm, a thick oil of a fetid and empyreumatic ſmell, and much volatile alkali. Its reſidue is a ſpungy coal of a brilliant and metallic aſpect, difficult to incinerate, and which when heated with the vitriolic acid affords vitriols of ſoda and of iron. After theſe operations, a mixture of calcareous phoſphate and coaly matter remains. The clot of blood putrefies very quickly in warm air. When waſhed with water, it is ſeparated into two very diſtinct ſubſtances, one of which is diſſolved, gives the fluid a red colour, and the ſolution, when heated with different menſtrua, exhibits all the characters of ſerum; but it contains a much greater quantity of iron, which may be obtained by incineration of the coal, and ſubſequent waſhing, to ſeparate the ſaline matters. The reſidue of this waſhing is ſaffron

ſaffron of Mars, of a beautiful colour, and uſually attracted by the magnet. The colour of blood is attributed to this metal. Iron has been obtained from blood in conſiderable quantities, by Menghini, Rouelle, and Bucquet.

The clot, after having been waſhed, and deprived of all its red ſerum, appears to conſiſt of a white fibrous matter, which remains to be examined.

The fibrous part of the blood is white, colourleſs, and inſipid, after it has been well waſhed. By diſtillation on the water-bath, it affords a taſteleſs phlegm of a faint ſmell, and capable of putrefaction. The moſt gentle heat ſingularly hardens the fibrous matter: when ſuddenly expoſed to a ſtrong heat, it ſhrinks up like parchment. By diſtillation in a retort, it affords an alkaline phlegm, a ponderous, thick, and very fetid oil, with much ammoniacal chalk contaminated by a portion of oil. Its coal is not bulky, but compact and heavy, and is leſs difficult to incinerate than that of the lymph. Its aſhes are very white, and contain neither ſaline matter nor iron; which doubtleſs were carried off by the previous waſhing: the appearance of theſe aſhes is earthy, and they ſeem to conſiſt of calcareous phoſphate.

The fibrous part in the blood putrefies very quickly, and with great facility; when expoſed to a hot and moiſt air, it ſwells, and

and affords much volatile alkali. It is not ſoluble in water; when boiled with that fluid it hardens and aſſumes a grey colour. Alkalis do not diſſolve it; the moſt feeble acids combine with it. The nitrous acid diſengages much mephitis, as Mr. Berthollet has obſerved, and afterwards diſſolves it with effervеſcence, and diſengagement of nitrous gas; when all this gas is diſengaged, oily and ſaline flocks are obſerved in the reſidue, which float in a yellowiſh liquor; by evaporating this liquor cryſtals are obtained, analogous to the acid of ſugar, or oxaline acid (ſee the Additions to the Vegetable Kingdom), and a conſiderable quantity of flocks formed of a peculiar oil and calcareous phoſphate is depoſited. There ſeem to be two oils in the fibrous part; one, which, with the oxyginous principle, conſtitutes the oxaline acid; the other, which with the ſame principle, forms the maluſian acid.

The fibrous matter is likewiſe ſoluble in the muriatic acid, which cauſes it to aſſume the form of a green gelly. The acid of vinegar diſſolves it with the aſſiſtance of heat: water, and more particularly alkalis, precipitate the fibrous matter when diſſolved in acids. This animal ſubſtance is decompoſed in theſe combinations; and when ſeparated from the acids by any method, it no longer preſents the ſame properties.

The neutral ſalts, and other mineral ſub-

ſtances,

ſtances, do not act upon it. It unites to the lymph, eſpecially that which is coloured, to form the clot. This laſt, like the fibrous part, is totally ſoluble in acids; doubtleſs, on account of the combination of this matter with the red ſerum. Hence we ſee, that the fibrous part differs greatly from the albuminous matter. It is a ſubſtance more perfectly animalized than this laſt; a kind of animal gluten, which greatly reſembles that of flour; and which more eſpecially poſſeſſes the remarkable property of becoming concrete, by cooling and reſt. It cannot be doubted, but that this matter, which has not hitherto been diſtinctly obſerved by phyſiological and pathological phyſicians, is of the greateſt conſequence in the animal economy. I have long ſince obſerved, that it is depoſited in the muſcles, conſtituting the fibrous baſe of theſe organs, and that it forms the ſubſtance which is moſt eminently irritable. Whence I have inferred, that it is of conſequence to pay a greater attention to this ſubſtance than has hitherto been done; and to conſider it as capable by its abundance or deviation of cauſing peculiar diſorders. And I have exhibited the proofs of theſe uſeful medical conſiderations in a Memoir, which will be inſerted in the volume of the Royal Society of Medicine for the year 1783, &c.

Notwithſtanding theſe reſearches into the nature

into the nature of blood, much remains to be done before its chemical properties will be perfectly known. The intimate difference between the ſerum and the fibrous part is yet unknown: neither has blood been yet examined in all its ſtates; eſpecially in the different diſorders which conſiderably alter this fluid; as for example, in ſtrong inflammations, in the chloroſis, ſcorbutic diſorders, &c. Phyſicians judge of theſe alterations merely by the external appearance, and it is much to be wiſhed that their nature were better aſcertained by accurate analyſis.

Rouelle has examined the blood of ſeveral quadrupeds, ſuch as the ox, the horſe, the calf, the ſheep, the hog, the aſs, and the goat; he obtained the ſame products as from the human blood, but in different proportions.

CHAP. XI.

Concerning Milk.

MILK is a recrementitial humour deſigned to nouriſh young animals in the early part of their life. It is of an opake white colour, a mild ſaccharine taſte, and a ſlightly aromatic ſmell. It is ſeparated immediately

immediately from the blood in the breafts or udders of the female animals, to which it is conveyed principally by the arteriæ mammariæ. Man, quadrupeds, and cetaceous animals, are the only creatures which afford milk. All other animals are deftitute of the organs which fecrete this fluid.

Milk differs greatly in the feveral animals; in the human fpecies it is very fweet or faccharine; the milk of the cow is mild, and its principles are well connected; that of the goat and afs have a peculiar virtue, as they are often flightly aftringent. The variable properties of milk depend ufually on the food of the animal.

Cows milk, which is taken as an example of the analyfis, becaufe it is eafily procured, is a compound of three different fubftances, ferum, or whey, which is fluid and tranfparent; butter and cheefe, which are more confiftent. Thefe three parts are fo mixed as to form a kind of animal emulfion.

Milk diftilled by the heat of a water-bath, affords a tafteless phlegm of a faint fmell, and capable of putrefaction. By a degree of heat fomewhat ftronger, it coagulates like the blood, according to the obfervation of Bucquet; by agitation, and gradual drying, it forms a kind of faccharine extract, called franchipane. This extract, diffolved in water, conftitutes the whey of Hoffman; the extract diftilled by a naked fire affords acid,

acid, fluid oil, concrete oil, and ammoniacal chalk. Its coal contains a ſmall quantity of vegetable alkali, febrifuge ſalt, and calcareous phoſphate.

Milk, when expoſed to a hot temperature, is capable of undergoing the ſpirituous fermentation, and forming a kind of wine; but it is neceſſary that the quantity ſhould be large. The Tartars prepare a ſpirituous liquor with mares milk. Milk quickly becomes acid, and coagulates. The caſeous part becomes ſolid, and the ſerum ſeparates.

Acids immediately produce the ſame effects on milk; they coagulate it, but alkalis, more eſpecially the volatile alkali, re-diſſolve this coagulum. Boerhaave affirms, that milk, when boiled with oil of tartar, becomes firſt yellow, afterwards red, and of the colour of blood. He even thinks, that it is a ſimilar combination, which cauſes the milk to be converted into true blood in the human body. Neutral ſalts, ſugar, and gum, likewiſe coagulate milk by the aſſiſtance of heat, according to the obſervation of Scheele.

To prepare whey, milk is heated, and twelve or fifteen grains of rennet is added to every pint. This ſubſtance, formed by the mixture of milk, turned ſour in the ſtomach of calves, and of the gaſtric juice, is a ferment which coagulates the caſeous part. When the coagulation is made, the whey is ſtrained from the curd. Gallium, the

the flowers of the thiſtle, and of artichoke, act in the ſame manner as rennet upon milk. The internal membrane of the ſtomach of calves, and of birds, dried and pulverized, produces the ſame effect upon milk; which proves that the coagulation is produced by the gaſtric juice, dried and contained in the pores of this membrane.

Serum, or whey, prepared in this manner, is turbid; it may be clarified by white of egg, or cream of tartar. When the ſerum, or whey, is required to be very pure, for the purpoſe of examining its nature, cream of tartar muſt not be added.

Whey has a mild taſte. When prepared with new milk, it contains a ſaccharine eſſential ſalt, but it ſoon acquires an acid taſte, by the eſtabliſhment of the acid fermentation. This change is produced by the alteration of a mucilaginous principle, contained in the milk; and it is the developement of this acid which occaſions the ſpontaneous ſeparation of the whey from the other ſubſtances contained in milk. It is therefore neceſſary to examine the acid, which is formed in milk, and conſtitutes fermented whey. It is a well known fact, that milk left expoſed in a temperature of ſeventy or eighty degrees, experiences, in a few days, a fermentation which developes an acid, and ſeparates the butter and cheeſe. The acid, formed by this fermentation, and which

which is as ſtrong as it will be at the end of twelve or fifteen days, has been examined by Mr. Scheele, and is called the galactic acid by M. de Morveau. The following is the proceſs uſed by Scheele, to obtain it in a ſtate of purity. After having attempted, in vain, to ſeparate the acid by diſtillation from ſour whey, by which he obtained only a ſmall quantity of vinegar, he evaporated the whey to one eighth, after having filtrated it, to ſeparate all the caſeous matter. From this he precipitated the animal earth, by lime-water. He then diluted the fluid with three times its weight of water, and ſeparated the lime by the acid of ſugar; at the ſame time taking care that this laſt acid ſhould not remain diſengaged in the ſolution, which was eaſily aſcertained and prevented, by the addition of ſucceſſive ſmall portions of lime-water. The ſugar of milk, and ſeveral other foreign ſubſtances, were then ſeparated, by the addition of ſpirit of wine, which eaſily diſſolves the acid of milk. Laſtly, the decanted ſolution being diſtilled, the ſpirit of wine paſſed over, and the pure galactic acid remained in the retort. Scheele has obſerved the following properties in this acid.

When ſtrongly evaporated, it did not afford cryſtals, but attracted the humidity of the air: by diſtillation, it afforded an empyreumatic acid, reſembling ſpirit of tartar; a ſmall

a ſmall quantity of oil, and a mixture of cretaceous acid and inflammable gas.

With the three alkalis, and alſo with ponderous earth and lime, it forms deliqueſcent ſalts. Its combination with magneſia cryſtallizes, but likewiſe attracts the moiſture of the air. It does not at all attack cobalt, biſmuth, antimony, mercury, ſilver, or gold, even by the heat of ebullition. It diſſolves zink and iron, producing inflammable gas; the firſt of theſe ſalts, called by Morveau the galacte of zink, cryſtallizes; the ſecond, or the galacte of iron, forms a brown deliqueſcent maſs. The galactic acid calcines, and diſſolves copper and lead. The galactic ſolution of the latter metal depoſits a ſmall quantity of vitriol of lead, which indicates the preſence of a ſmall quantity of vitriolic acid in this animal acid. Laſtly, it decompoſes the acetous ſalt of pot-aſh; a property which, together with moſt of thoſe here mentioned, denotes, as M. de Morveau obſerves, that the galactic acid differs from vinegar. M. Scheele adds, likewiſe, that a true vinegar may be obtained from milk, by mixing ſix ſpoonfuls of ſpirit of wine with three pints of milk, and ſuffering the mixture to ferment in a well-cloſed veſſel. The gas, which is diſengaged during this fermentation, muſt be ſuffered to eſcape, from time to time; and at the end of a month the milk is changed

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into good vinegar, which may be ſtrained through a cloth, and preſerved in bottles. This celebrated Swediſh chemiſt likewiſe adds, that milk, in a bottle whoſe neck is plunged in a veſſel filled with the ſame liquor, and expoſed to a heat ſomewhat ſtronger than that of ſummer, undergoes a fermentation which affords a large quantity of elaſtic fluid. This laſt fluid diſplaces the milk, and almoſt intirely empties the bottle, at the end of two days. The acid produced in this fermentation, which takes place without the contact of air, appears to receive its oxyginous principle, or acidifying baſe of the air, from the decompoſition of the water.

The ſerum of milk, or whey, made by means of rennet, and not yet become ſour, holds in ſolution a certain quantity of a ſaline ſubſtance, known by the name of ſalt, or ſugar of milk. Though Kempfer affirms that the Brachmans were acquainted with the proceſs for preparing this ſalt, it appears that it was firſt mentioned by Fabricius Bartholet, or Bartholdi, an Italian phyſician, in the year 1619. Etmuller, Teſti Werloſchnigg, Walliſnieri, Fickius, and Cartheuſer, have ſucceſſively ſpoken of this ſubſtance, and deſcribed the methods of obtaining it. Meſſrs. Vulgamoz and Lichtenſtein have very well deſcribed the method of obtaining this ſaline ſubſtance, which is prepared

pared in large quantities in ſeveral parts of Switzerland. The whey obtained from ſkimmed milk, coagulated with rennet, is evaporated to the conſiſtence of honey; after which it is put into moulds, and dried in the ſun. This is the ſugar of milk in cakes, and is diſſolved in water, clarified with whites of eggs, evaporated to the conſiſtence of ſyrup, and cryſtallized in the cold. By this treatment it affords white cryſtals, in rhomboidal parallelipipedons; the mother water depoſits yellow and brown cryſtals, which are purified by ſucceſſive ſolutions. Mr. Lichtenſtein has examined and analyzed the different ſugars of milk, which are ſold at various prices in Switzerland, and has more particularly diſtinguiſhed, 1. The ſweet ſugar of milk, which is of a white colour, obtained from ſweet and purified whey. 2. The aceſcent ſugar of milk, obtained from ſour whey. 3. The ſugar of milk, rendered impure by fat ſubſtances; which ſeparate, according to him, in the firſt cryſtallization. 4. Sugar of milk, mixed with oil and common ſalt, which cryſtallizes the laſt. 5. Sugar of milk, mixed with fat matter, common ſalt, and ſal-ammoniac. It is adheſive and moiſt, and affords volatile alkali on the addition of fixed alkali. 6, And laſtly, Sugar of milk, mixed with all the before-mentioned ſubſtances, and likewiſe with extractive and caſeous matter.

This laſt is of the conſiſtence of honey, becomes rancid, and is acrid and diſagreeable.

Sugar of milk, when very pure, has a ſlightly ſaccharine, faint, and as it were earthy taſte; it always loſes by ſucceſſive ſolutions. It is ſoluble in three or four parts of boiling water; and, according to Scheele, Rouelle, and Vulgamoz, it affords the ſame products as ſugar by diſtillation. Rouelle obtained from a pound of this ſalt, by burning it, 24 or 30 grains of aſhes; three-fourths of which were febrifuge ſalt, or muriate of pot-aſh, and one-fourth chalk of pot-aſh, or mild vegetable alkali. On a red-hot coal, ſugar of milk melts, boils up, emits an odour of caramel, and burns like ſugar. Theſe properties appear to indicate, that this ſalt is capable of affording the acid of ſugar; and Mr. Scheele has ſhewn, by his experiments, that it does: but he obſerved, that a large quantity of ſpirit of nitre is required for this purpoſe; that four ounces of ſugar of milk afford five grains of ſaccharine acid; and he has alſo diſcovered, that if the reſidues of ſugar of milk be treated by the nitrous acid, and filtrated, in order to cryſtallize the ſaccharine acid by evaporation, a white powder remains on the filter; which he found to be a peculiar acid, and named it the acid of ſugar of milk. He obſerved, that it poſſeſſes the following properties.

It has the form of a white granulated powder;

powder; two drachms of this ſalt, very pure, being heated in a glaſs retort, melted, ſwelled up, and became black; a brown ſalt, of a mixed ſmell of benzoin and amber, ſublimed, weighing 35 grains; this ſalt was acid, ſoluble in ſpirit of wine, more difficultly in water, and burned on charcoal. The receiver contained a liquor of a brown colour, and not of an oily nature; eleven grains of charcoal remained in the retort. Cretaceous acid and inflammable gas were diſengaged during this diſtillation. The acid of ſugar of milk is very ſparingly ſoluble in water, one ounce of boiling water diſſolving only ſix grains; one-fourth of which was precipitated by cooling. According to M. de Morveau, this acid efferveſces with the hot ſolution of cretaceous vegetable alkali. A cryſtallized ſalt was obtained, by cooling, which was ſoluble in eight times its weight of hot water, and cryſtallized again by cooling. The ſalt it formed with the mineral alkali was cryſtallizable, but required no more than five parts of water for its ſolution. This acid combines likewiſe with the volatile alkali; the neutral ſalt, thus produced, loſes its alkali by heat. With ponderous earth, clay, magneſia, and lime, it forms ſalts, nearly inſoluble. It acts but very feebly on the metals, and forms with their calces ſalts of difficult ſolubility. It

precipitates the nitres of mercury, lead, and ſilver, as well as the muriate of lead.

Mr. Scheele, when he firſt made this diſcovery, ſuppoſed that the white powder, depoſited by the ſaccharine acid obtained from ſugar of milk by means of the nitrous acid, was merely a proportion of the calcareous ſalt, formed by the ſaccharine acid and a proportion of the lime, which might be contained in that animal ſalt. But he was ſoon undeceived, by pouring a ſmall quantity of ſaccharine acid into a ſolution of ſugar of milk; as the mixture afforded no precipitate. Nevertheleſs, Mr. Hermſtadt, who has publiſhed two memoirs in Crell's Chemical Journal, the ſecond of which treats particularly of this acid earth, thinks, notwithſtanding the experiments of Scheele, that it is a compound of ſaccharine acid, calcareous earth, and a fat ſubſtance. But M. de Morveau, after examining the experiments of this chemiſt, with his uſual accuracy, and comparing them with thoſe of Scheele, has ſhewn, in the new Dictionaire Encyclopedique, that Mr. Hermſtadt has not accompliſhed his undertaking, and that, even from his own reſults, the diſcovery of the Swediſh chemiſt is rather confirmed than deſtroyed. M. de Morveau has likewiſe made ſeveral ingenious experiments which confirm this aſſertion. To theſe accounts we may add, that the acids of milk, and of ſugar

ſugar of milk, do not exiſt ready formed in ſugar of milk, and that this ſalt contains only the baſes, which take the oxyginous or acidifying principle from the nitrous acid. We may likewiſe obſerve, that ſubſequent experiments will probably ſhew, that the acid of ſugar of milk is nothing more than a modification of ſome other vegetable acid; for every circumſtance tends to prove, that the principles of whey are derived from the vegetables on which the animals ſubſiſt.

The Baron de Haller has given the following proportions of the ſugar contained in the milk of different animals.

Four ounces of ſheep's milk, afforded of

Sugar of milk	-	35 or 37 grains.
Goat's milk	afforded	47 — 49
Cow's milk	- -	53 — 54
Human milk	-	57 — 58
Mare's milk	- -	69 — 70
Aſs's milk	- -	80 — 82

Rouelle has obſerved, that the whey of cow's milk, from which the ſugar of milk has been extracted, takes the form of jelly by cooling; and he conſequently admits it to contain gelatinous matter.

Cheeſe, or the caſeous matter, takes the ſolid form, and is ſeparated from the other conſtituent parts of milk, by the action of fire, by the acid fermentation, and by the mixture of acids. This matter, when well

washed, is white, solid, and as it were fibrous; the action of a gentle heat hardens it. Distillation on a water-bath extracts an insipid phlegm, which putrefies.

Dried cheese, distilled in a retort, affords an alkaline phlegm, a ponderous oil, and much concrete volatile alkali. Its coal is dense, very difficultly incinerated, and does not afford fixed alkali. When this coal is treated with nitrous acid, it is found to contain lime, and the phosphoric acid.

Cheese putrefies in a hot temperature; it swells, emits a nauseous smell, becomes imperfectly fluid, and is covered with a scum, or froth, arising from the disengagement of a very strong-smelling and mephitic gas, which escapes with difficulty from this viscid matter.

Cheese is insoluble in cold water; hot water hardens it. Mr. Scheele has observed, that when it has been precipitated by a foreign acid, boiling water dissolves a part.

Alkalis dissolve it, more particularly the volatile alkali, which, when poured in the quantity of a few drops into milk coagulated by an acid, causes the coagulum quickly to disappear.

The concentrated acids likewise dissolve cheese; spirit of nitre disengages mephitis; but the vegetable acids do not sensibly dissolve it. Its solution in the mineral acids is precipitated

tated by the alkalis, which rediſſolve it if added in too great a quantity.

The neutral ſalts, more particularly marine ſalt, retard its putrefaction.

From all theſe facts it appears, that cheeſe is a ſubſtance greatly reſembling lymph; but as it is not itſelf ſoluble in water, it is originally ſuſpended in milk, by virtue of the gelatinous mucilage, and the extractive and ſaccharine ſubſtances contained in that fluid.

Butter is partly ſeparated from milk by reſt: it is collected at the ſurface, but as it is mixed with much ſerum, and caſeous matter, it is more completely ſeparated by ſtrong agitation, in which the art of making butter conſiſts. The ſerum, from which butter is ſeparated by agitation, retains a portion of this oily ſubſtance, and is yellow, ſour, and fat; it is called butter-milk. Cream is a mixture of cheeſe and butter, which is ſkimmed off the ſurface of milk that has ſtood for ſome time. It is much more difficult of digeſtion than milk itſelf. If cream be ſtrongly agitated, it takes the form of froth, and is then called whipt cream.

Pure butter is concrete and ſoft, of a yellow colour, approaching more or leſs to that of gold, and of a mild agreeable taſte. It melts by a gentle heat, and becomes ſolid by cooling. When diſtilled on a water-bath, it affords a phlegm nearly inſipid. By a ſtronger

a ſtronger heat, it affords a very penetrating and ſtrong acid, a fluid oil, and afterwards a concrete coloured oil, of the ſame penetrating ſmell as the acid. By rectifying theſe products, the oil is rendered as fluid and volatile as eſſential oils. The remaining coal is not abundant. The acid obtained from butter, by diſtillation, ſeems to be of the ſame nature as that of fat, which we ſhall hereafter mention by the name of the ſebaceous acid. It may likewiſe be obtained in the ſtate of neutral ſalts, by the addition of lime or the fixed alkalis.

Butter ſoon becomes ſour and rancid in a hot air. Its acid is then developed, and its taſte is diſagreeable. Water, and ſpirit of wine, in ſome meaſure reſtore its original taſte, by diſſolving the acid. The fixed alkalis diſſolve butter, and form a kind of ſoap, which is little known.

Hence we find, that butter is an oily ſubſtance, of the nature of the fat vegetable concrete oils.

Freſh butter is mild, temperate, and relaxing. But it readily becomes ſour, and in general agrees with few ſtomachs. Rancid butter, whoſe acid is developed, is one of the moſt unwholſome and indigeſtible of all foods.

Milk is an agreeable food, of conſiderable uſe in a great number of caſes; it is even one of the moſt valuable medicines we poſ-

ſeſs.

ſeſs. It corrects the acrid humours in diſorders of the ſkin, and of the articulations. It cicatrices ulcers of a good kind. It may be charged with the aromatic parts of plants, and is then an excellent remedy in the pulmonary conſumption. All ſtomachs, however, do not digeſt milk. Such perſons as are inclined to acidities in the firſt paſſages, are uſually incommoded by it; and in general it ought to be adminiſtered prudently. Milk, rendered medicinal, by cauſing the animal which gives it to take different ſubſtances, is often uſed with ſucceſs in various diſorders.

The milk of different animals have certain peculiar virtues; that of the human ſpecies is mild, of a ſaccharine taſte, and is greatly ſerviceable in the maraſmus. The milk of the aſs is ſucceſsfully uſed in the pulmonary conſumption, and the gout: it uſually relaxes. Mare's milk reſembles that of the aſs. Goat's milk is ſerous, and lightly aſtringent. Cow's milk is the thickeſt, the fatteſt, and the moſt nouriſhing; it is likewiſe the moſt difficult of digeſtion, and often requires to be diluted with water, or with ſome aromatic infuſion, eſpecially if it does not eaſily paſs off, or produces coſtiveneſs.

Milk is likewiſe uſed externally, as a ſoftening and emollient remedy. It mitigates pain, ripens gatherings and abſceſſes, and haſtens ſuppuration. It is applied hot, and incloſed in a bladder on the diſeaſed parts.

CHAP.

CHAP. XII.

Concerning Fat.

FAT is a concrete oily matter, contained in the cellular membrane of animals; it is white, or yellowiſh, with little or no ſmell or taſte, and differs in all animals in its ſolidity, colour, taſte, &c. and likewiſe in the ſame animal, at different ages. In infancy it is white, inſipid, and not very ſolid; in the adult it is firm, and yellowiſh; and in animals of an advanced age, its colour is deeper, its conſiſtence various, and its taſte in general ſtronger. The fat of man, and of quadrupeds, is conſiſtent, white, or yellow. That of birds is finer, ſweeter, more unctuous, and in general leſs ſolid. In cetaceous animals and fiſhes, it is almoſt fluid, and frequently placed in peculiar reſervoirs, as in the cavity of the cranium. It is likewiſe found in ſerpents, inſects, and worms; but in theſe animals it is only met with among the viſcera of the lower belly, on which it is placed in ſeparate portions; being ſcarcely ever obſerved but in minute quantities, on the muſcles or beneath the ſkin.

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It has been obſerved, that the fat of frugivorous and herbivorous animals is firm and ſolid, while that of carnivorous animals is more or leſs fluid. It muſt, however, be remarked, that the fat is always leſs ſolid and concrete, in the warm and living animal, than in the ſame animal when dead and cold, in the hands of the diſſector.

Fats vary, according to the parts of the animal from which they were taken: it is ſolid near the reins, and beneath the ſkin; it is leſs firm between the muſcular fibres, or near moveable viſcera, ſuch as the heart, the ſtomach, and the inteſtines. It is more abundant in winter than in ſummer; it appears deſtined to maintain the heat in thoſe regions wherein it is placed, as many facts, collected by phyſiologiſts, demonſtrate. It even appears to contribute to the nouriſhment of animals, as is obſervable in bears, the mountain rat, the dormouſe, &c. and in general all animals, forced to long abſtinence, in which the fat melts, and gradually diſappears.

To prepare fat for pharmaceutical purpoſes, it muſt be cut in pieces, and the membranes and veſſels ſeparated; it is afterwards to be waſhed with much water, and melted in a new earthen veſſel, with the addition of a ſmall quantity of water; when this fluid is diſſipated, and the ebullition ceaſes, it muſt be poured

poured into a glazed earthen veſſel, where it fixes, and becomes ſolid.

Fat has not yet been examined ſufficiently to aſcertain all its chemical properties. The action of fire, air, and certain menſtruums, on this ſubſtance, only are known. It is nevertheleſs highly neceſſary to be perfectly acquainted with this animal ſubſtance, in order to judge of its uſes; concerning which nothing is yet certainly known, and more eſpecially the alterations it is ſubject to in living bodies.

The fat of any animal, expoſed to a gentle heat, liquifies, and congeals by cooling. If it be ſtrongly heated, with contact of air, it emits a ſmoke of a penetrating ſmell, which excites tears and coughing, and takes fire when ſufficiently heated to be volatilized: the charcoal it affords is not abundant. If fat be diſtilled on a water-bath, an inſipid water of a ſlight animal ſmell, is obtained, which is neither acid nor alkaline, but which ſoon acquires a putrid ſmell, and depoſits filaments of a mucilaginous nature. This phenomenon, which takes place with the water obtained by diſtillation on the water-bath, from any animal ſubſtance, proves, that this fluid carries up with it a mucilaginous principle, which is the cauſe of its alteration. Fat, diſtilled in a retort, affords phlegm, at firſt aqueous, and afterwards ſtrongly acid; an oil, partly liquid, and partly

partly concrete; a very ſmall quantity of charcoal, exceedingly difficult to incinerate, in which Mr. Crell found a ſmall quantity of calcareous phoſphate. Theſe products have an acid and penetrating ſmell, as ſtrong as that of the ſulphureous acid. The acid is of a peculiar nature, and has been carefully examined by Mr. Crell; but as it is very difficult to obtain by diſtillation, this celebrated chemiſt has uſed a much more certain and expeditious proceſs, which we ſhall preſently deſcribe. The concrete oil may be rectified, by repeated diſtillation, ſo as to become very fluid, volatile, and penetrating; in a word, to preſent all the characters of a true eſſential oil. Twenty-eight ounces of human fat afforded Mr. Crell twenty ounces five drachms forty grains of fluid oil, three ounces three drachms and thirty grains of ſebaceous acid, three ounces one drachm four grains of a brilliant charcoal, conſiderably reſembling plumbago, as M. de Morveau remarks. Five drachms ſix grains of matter were loſt in this analyſis, which may be attributed to the water in vapour, and the elaſtic fluids, becauſe Mr. Crell did not uſe the pneumato-chemical apparatus.

Fat expoſed to a hot air, alters very quickly; the mild, and ſcarcely ſenſible ſmell, is changed to ſtrong rancidity. This alteration appears to conſiſt of a true fermentation,

mentation, by which the acid is developed and diſengaged. Though this acid appears to be of the nature of the ſebaceous acid, yet I cannot think that the oily part of the fat is the ſole cauſe of the change, but that the peculiar animal mucilage, which ſubſequent analyſis will diſcover, has alſo a ſhare in it. Rancid fat may be corrected by two methods: water is capable of carrying off the acid it contains, as Mr. Poerner has obſerved; ſpirit of wine has the ſame property, according to Mr. Machy. This proves, that a part of rancid fat is put into a ſaponaceous ſtate by its acid, and by that means rendered ſoluble in water, and in ſpirit: either of theſe fluids may therefore be uſed with ſucceſs to deprive fat of its rancidity.

When fat is waſhed with a great quantity of diſtilled water, the fluid diſſolves a gelatinous matter, which may be exhibited by evaporation; but the fat always retains a certain portion of this matter, with which it is intimately combined, and on which its property of fermenting depends. The action of water on this animal ſubſtance has not yet been further inquired into.

Meſſrs. Crell, and the chemiſts of Dijon, have explained the action of alkaline ſubſtances on fat. It has been long ſince known, that the pure alkalis form a kind of ſoap with fats. Mr. Crell, by treating ſoap with a ſo-

a ſolution of alum, ſeparated the oil, and obtained a ſolution of the ſebaceous ſalt of vegetable alkali by evaporating the fluid. He diſtilled this ſalt with oil of vitriol, which diſengaged the ſebaceous acid. To deprive this of the portion of vitriolic acid it may be contaminated with, Mr. Crell directs it to be re-diſtilled from one-fourth of the ſebaceous ſalt of pot-aſh, which muſt be reſerved for this uſe. It may be aſcertained that it contains no more vitriolic acid by the addition of the acetous ſalt of lead: for if the precipitate be totally ſoluble in vinegar, it does not contain vitriolic acid. The chemiſts of the academy of Dijon uſe a more ſimple proceſs to obtain the ſebaceous acid. Suet is melted, and quick-lime added; when the mixture is cold, it is boiled in a large quantity of water, which, by filtration and evaporation, affords the ſebaceous ſalt of lime, of a brown colour, and acrid taſte. This is purified by calcination in a crucible, ſolution, and filtration; a ſufficient quantity of water, impregnated with cretaceous acid, being added, to ſeparate the ſuperabundant lime. The fluid being evaporated, affords a white ſalt, from which, by diſtillation with the vitriolic acid, the ſebaceous acid is diſengaged.

This acid exiſts in the butter of cocoa, ſpermaceti, and probably in vegetable oils. The following are its characters: it is li-

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quid, white, and of a very ſtrong ſmell; it emits white fumes, is decompoſed by fire, becomes yellow, and affords cretaceous acid. It ſtrongly reddens blue colours; unites, in all proportions, with water; forms a cryſtallizable ſalt with lime; and with pot-aſh and ſoda, ſalts which cryſtallize in needles, and are fixed in the fire. It appears to act on quartz, and on glaſs, like the acid of ſyrup. (See § IV. of the diſcourſe placed at the beginning of the firſt volume.) It diſſolves gold, when united with the nitrous acid; attacks mercury and ſilver; precipitates the nitre and acetous ſalt of lead; it precipitates cream of tartar, and ſeparates the vinegar from tartar, and from the acetous ſalt of pot-aſh. When ſtrongly heated on vitriolic ſalts, it ſeparates the acid in the ſulphureous ſtate. It precipitates the nitre of mercury and of ſilver. Many of theſe properties induced Mr. Crell to think, that the ſebaceous acid might be nothing more than a modification of the muriatic acid; but M. Morveau obſerves, that as it decompoſes corroſive ſublimate, that character alone is ſufficient to diſtinguiſh them.

Acids produce a change in fat, which is ſimilar to that produced by combuſtion. They likewiſe appear capable of converting it into an acid ſoap, ſoluble in water.

Sulphur unites very well with fat, and forms a combination, which has not yet been accurately examined.

Fat

Fat is capable of diſſolving certain metals; it unites with mercury, in the well known preparation, called mercurial ointment. For this purpoſe, the metal is triturated with hogs lard for a long time; the mercury becomes divided, attenuated, and ſo intimately united with fat, that it communicates to it a ſlate-colour, and loſes its metallic form. This union, however, appears to be nothing more than an extreme diviſion, or at moſt there is only a ſmall portion of the mercury diſſolved by the acid of the fat, ſince globules of mercury may always be diſtinguiſhed by a lens in the beſt prepared ointment.

Lead, copper, and iron, of all the metals are the moſt eaſily altered by fat. The calces of theſe metals combine very readily with this ſubſtance; and for that reaſon it is dangerous to leave food of a fat nature in veſſels of copper, or even in thoſe of earth, which are covered with glaſs of lead. In the combinations of fat with the calces of metals, it is obſerved, that the latter aſſume readily the metallic ſtate when heated: this phenomenon ariſes from the inflammable gas, which is diſengaged from the fat, and unites with the oxyginous principle of the calx.

Moſt vegetable matters are capable of uniting with fat; extracts and mucilages give it a degree of ſolubility in water, or at leaſt favour its ſuſpenſion in that fluid.

It combines with oils in all proportions, and communicates to them a part of its consistence.

These are the chemical properties of fat which are at present known: they teach us, that this substance greatly resembles butter; that is to say, it is a kind of fat oil, rendered concrete by a portion of acid.

With regard to its uses in the animal economy, besides that of maintaining the heat of those parts which it surrounds, and the agreeable plumpness and pliancy it produces, together with the whiteness it communicates to the skin: it likewise appears, according to Macquer, to be of use in absorbing the superabundant acids which may exist in the bodies of living creatures; it is, as it were, the reservoir of those salts. It is likewise known, that too great a quantity of acid, introduced into the body of an animal, dissolves and melts the fat, doubtless by rendering it saponaceous, and consequently more soluble. The excessive abundance, and more especially the alterations of the fat, produce dangerous disorders in the animal economy, whose symptoms and effects have not yet been well examined. Lorry has particularly attended to the nature of fat, and has discovered a striking analogy between this substance and bile. Fat is used in foods, and is nourishing for such persons as have strong digestive powers. It is used externally in medicine, as a softening

ening remedy ; and as ſuch it enters into the compoſition of ointments and plaſters.

The marrow, contained in long bones, exhibits the ſame properties as fat ; but the comparative analyſis has not been yet made with ſufficient accuracy to deſcribe its characteriſtic properties.

CHAP. XIII.

Concerning the Bile and Biliary Calculi.

THE bile, or gall, is a fluid of a green colour, more or leſs yellow, of an exceſſively bitter taſte, and of a faint and nauſeous ſmell, which is ſeparated from the blood by a glandulous viſcus, univerſally known by the name of the liver. It is collected in moſt animals, except inſects and worms, in a receptacle near the liver, called the gall bladder. The human bile has not yet been much examined, on account of the difficulty of procuring a ſufficient quantity: the gall of the ox has been more particularly examined by chemiſts.

This liquor is of a glutinous, or almoſt gelatinous conſiſtence ; it pours out like ſyrup ; and by agitation, it lathers like ſoap-water.

When diſtilled in the water-bath, it affords a phlegm, which is neither acid nor alkali, but after a certain time putrefies. This phlegm has often exhibited to me a ſingular character; it emits an odoriferous ſmell, of conſiderable ſtrength, and greatly reſembling that of muſk or amber. This experiment has been made in my courſes of lectures before a number of ſpectators. It takes place, more eſpecially when bile, ſlightly altered by having been kept ſome days, is ſubmitted to diſtillation. When all the water which bile affords in the water-bath has been diſtilled off, the reſidue has the form of an extract, more or leſs dry, and of a deep and browniſh green. This extract of bile attracts the humidity of the air, is very tenacious and pitchy, and is totally ſoluble in water; by deſtructive diſtillation, it affords volatile alkali, empyreumatic animal oil, much concrete volatile alkali, and an elaſtic fluid, conſiſting of a mixture of cretaceous and inflammable gas; after this operation, a coal remains of conſiderable bulk, and leſs difficult to incinerate than thoſe we have hitherto ſpoken of. According to Mr. Cadet, who communicated a very valuable memoir, on the analyſis of bile, to the Academy, in the year 1767, this coal contains mineral fixed alkali, a ſalt which he thinks to be of the ſame nature as ſugar of milk, an animal earth, and a ſmall portion of iron. It

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muſt be obſerved, that this diſtillation muſt be made ſlowly, becauſe the matter expands conſiderably. Bile, expoſed to a temperature between 65 and 85 degrees, quickly changes, its ſmell becomes more nauſeous, its colour is deſtroyed, whitiſh mucilaginous flakes are precipitated, its viſcidity diſappears, and its ſmell ſoon becomes fetid and penetrating. When the putrefaction is in an advanced ſtate, its ſmell becomes ſweet, and reſembles amber. My pupil, M. Vauguelin, has diſcovered, that bile, heated in the water-bath, and ſlightly evaporated, may be afterwards preſerved for many months without alteration, as is likewiſe the caſe with reſpect to vinegar.

Bile is very ſoluble in water; and when thus diluted, becomes of a yellow colour, which is lighter, in proportion to the quantity of water added.

All the acids decompoſe it in the ſame manner as ſoap, and produce a coagulum. If this mixture be filtrated, and the fluid evaporated, a neutral ſalt is obtained, which is found to conſiſt of the acid made uſe of and ſoda. This valuable experiment, firſt made by Mr. Cadet, proves the exiſtence of the mineral fixed alkali in the bile. The matter remaining on the filter, in theſe experiments, is thick, viſcid, very bitter, and very inflammable; its colour and conſiſtence vary, according to the nature and concentration of

the acid made uſe of. I have obſerved, that the vitriolic acid gives it a deep green colour; the nitrous acid, ſomewhat concentrated, a brilliant yellow; and the muriatic acid, a very beautiful light green: theſe colours, however, vary greatly, according to the ſtate of the bile, and of the acids. This precipitate is a true reſin, which ſwells, melts, and takes fire on hot coals, is totally ſoluble in ſpirit of wine, and precipitable by the addition of water. The action of acids on bile, proves, therefore, that it is a true ſoap, formed by an oil of the nature of reſins, combined with ſoda. They likewiſe indicate the preſence of a certain quantity of the albuminous matter in this animal fluid, which cauſes it to coagulate by fire, by acids, or by putrefaction.

Neutral ſalts, mixed with bile, prevent its putrefaction.

Metallic ſolutions, and bile, mutually decompoſe each other; the fixed alkali of this humour unites to the acid of the ſolution, and the reſin of the bile precipitates in combination with the metallic calx.

Bile unites readily with oils, and takes them out of cloaths in the ſame manner as ſoap.

This fluid is ſoluble in ſpirit of wine, which ſeparates the albuminous matter. The tincture of bile is not decompoſed by water; which ſhews, that this ſubſtance is

a true

a true animal ſoap, equally ſoluble in aqueous and ſpirituous menſtrua. Ether likewiſe diſſolves it very readily.

Vinegar decompoſes bile in the ſame manner as the mineral acids; when the filtrated liquor is evaporated, the acetous ſalt of ſoda is obtained, well cryſtallized.

From theſe ſeveral experiments, it follows, that bile is a compound of much water, a peculiar ſpiritus rector, albuminous mucilage, oil of the nature of reſins, and cretaceous ſoda. Mr. Cadet found it to contain a ſalt, which he thinks to be of the nature of ſugar of milk, and whoſe exiſtence has been ſince confirmed by Mr. Van Bochaute.

Bile, conſidered with reſpect to the animal economy, is a fluid which appears to aſſiſt the proceſs of digeſtion. Its ſaponaceous quality renders it capable of uniting oily ſubſtances with water. Its bitter taſte proves, that it ſtimulates the inteſtines, and promotes their action on the aliments. Roux, a celebrated phyſician and chemiſt of the Faculty of Medicine at Paris, whoſe premature death is a heavy loſs to the ſciences, was of opinion, that the bile is likewiſe principally calculated to evacuate the colouring part of the blood from the body. It appears to be decompoſed in in duodenum, by the acids which are almoſt always diſengaged in digeſtion. It is certain, at

at leaſt, that it is greatly altered, eſpecially in its colour, when it compoſes part of the excrements. Judicious phyſicians may therefore, in many caſes, make uſeful inferences from the inſpection of theſe matters, which indicate the ſtate of the bile, and that of the liver, which ſeparates it.

The extract of the gall of bullocks, and of many other animals, is uſed as a very good ſtomachic medicine. It ſupplies the defect and inactivity of the bile, reſtores the tone of the ſtomach, and eſtabliſhes the functions of that organ, when debilitated ; but great care muſt be taken in its uſe, becauſe it is acrid and heating ; and it muſt be adminiſtered only in very ſmall doſes, eſpecially in irritable ſubjects.

Whenever the human bile is detained in the gall bladder by any cauſe, and eſpecially by ſpaſmodic contractions, as in melancholic or hyſteric diſorders, long continued grief, &c. it thickens, and produces brown, light, inflammable concretions, of a very ſtrong bitter taſte, which are called biliary calculi. Theſe concretions are often very numerous, diſtending the gall bladder, and ſometimes intirely filling it. They produce violent hepatic cholics, vomiting, jaundice, &c.

Theſe calculi have been examined by M. Poulletier de la Salle. He has obſerved, that they are diſſoluble in ardent ſpirit. After

After having digeſted the ſtones in ſpirit of wine for a certain time, he obſerved, that the fluid was filled with ſlender, brilliant, and cryſtalline particles, having all the appearances of a ſalt; and the experiments made on this ſaline ſubſtance, ſhewed, that it reſembles, in certain properties, the acid ſalt, known by the name of flowers of benzoin. From the experiments of this philoſopher, it ſeems, that this ſalt is only contained in the biliary calculi of man, as he did not find it in thoſe of oxen.

The diſcovery of M. Poulletier de la Salle, has been confirmed by facts obſerved at the Royal Society of Medicine, reſpecting the ſtones of the gall-bladder. This ſociety received from ſeveral phyſicians, biliary calculi of a peculiar nature, which have not hitherto been deſcribed. They conſiſt of a maſs of cryſtalline tranſparent laminæ, ſimilar to mica, or talc, which have abſolutely the ſame form as the ſalt diſcovered by M. Poulletier. It even appears, that the human bile is capable of affording a great quantity of theſe cryſtals; for the Society of Medicine is in poſſeſſion of a gall-bladder intirely filled with this ſaline tranſparent concretion. It is much to be wiſhed, that the nature of theſe new calculi may be examined into, as reſearches on this ſubject cannot but be very uſeful to medicine.

From theſe accounts, two kinds of biliary

liary calculi may be diſtinguiſhed; the one, opake, brittle, inflammable, and truly bilious; the others tranſparent, cryſtallized in laminæ, and appearing to be a ſaline principle of the bile, which, though it has not yet been proved, may perhaps exiſt in greater quantities, in certain morbific affections of this fluid, than in the natural ſtate, and which in this caſe is diſpoſed to be precipitated and cryſtallized, whenever the gall is detained in conſiderable quantities in its bladder.

Soap, the mixture of oil of turpentine and ether, &c. have been propoſed to diſſolve the biliary calculi. It is an important obſervation, that they are only found in the gall-bladder of oxen, after dry ſeaſons, and a ſcarcity of freſh fodder; and that they diſappear in the ſpring and ſummer, when theſe animals find abundance of green and ſucculent vegetables. The butchers are well acquainted with this phenomenon; they know that theſe ſtones are found in oxen from the month of November to the month of March, and not afterwards. This phenomenon ſufficiently ſhews the power of the ſaponaceous juices of plants in diſſolving the biliary calculi.

CHAP.

CHAP. XIV.

Concerning the Saliva, the Pancreatic Juice, and the Gaſtric Juice.

ANATOMISTS and phyſiologiſts have obſerved a great analogy between the ſaliva and the pancreatic juice. The ſalivary glands, and the pancreas, have in fact a ſtructure intirely of the ſame kind, and the uſe of the fluids, ſecreted by theſe organs, appears to be the ſame. Man, and quadrupeds, are the only animals in which the ſaliva exiſts; or at leaſt the ſalivary glands have not been obſerved in any other animals.

No accurate chemical experiments have yet been made with theſe two fluids. This circumſtance may be attributed to the difficulty of procuring either, even in very ſmall quantities. It is only known, that the ſaliva is a very fluid juice, ſeparated by the parotides, and many other glands, which continually flows into the mouth, but moſt abundantly during maſtication. It appears to be of a ſaponaceous nature, impregnated with air, which renders it frothy; it leaves but a ſmall reſidue, when evaporated

porated to dryneſs ; but it forms, nevertheleſs, certain ſalivary concretions in the paſſages which convey it into the mouth. It appears to contain an ammoniacal ſalt, ſince lime and cauſtic fixed alkalis diſengage from it a penetrating and urinous odour. Pringle, from experiment, concluded, that the ſaliva is very ſeptic, and that it favours digeſtion, by exciting a commencement of putridity in the aliments. M. Spallanzani, and many other modern phyſicians, think, on the contrary, that it poſſeſſes the property of retarding and impeding putrefaction.

The gaſtric juice is ſeparated by ſmall glands, or the arterial extremities, which open into the internal tunic of the ſtomach. The oeſophagus likewiſe affords a ſmall quantity, eſpecially in the inferior region. Glands of conſiderable magnitude are obſerved in many birds, which open into very ſenſible excretory ducts.

Modern philoſophers have paid great attention to the gaſtric juice. Meſſrs. Spallanzani, Scopoli, Monch, Brugnatelli, Carminati, have, within the laſt few years, examined the properties of this liquor. They collected it in the ſtomach of ſheep and calves, by opening them, after having ſuffered them to faſt for ſome time. They obtained it from carnivorous and gallinaceous birds, by cauſing them to ſwallow ſpheres and tubes of metal, pierced with holes, and filled

filled with very fine ſpunge. M. Spallanzani examined the gaſtric juice of his own ſtomach, by procuring a vomit, or by ſwallowing wooden tubes, filled with different ſubſtances, to judge of the effect of the gaſtric juice on each of them. The experiments with tubes had been before attempted by M. De Reaumur. Laſtly, M. Goſſe of Geneva had the courage to cauſe himſelf to vomit a great number of times, by a proceſs which is peculiar to himſelf, and conſiſts in ſwallowing the air. From all the modern obſervations, the gaſtric juice appears to poſſeſs the following properties.

It is the principal agent of digeſtion, and changes the aliments into a kind of uniform ſoft paſte: it acts on the ſtomach itſelf after the death of animals. Its effects ſhew, that it is a ſolvent, but of that peculiar nature, that it diſſolves animal and vegetable ſubſtances uniformly, and without exhibiting a ſtronger affinity for the one than for the other. Far from being of the nature of a ferment, it is one of the moſt powerful antiſeptics we are acquainted with: and from the experiments of the philoſophers before cited, its nature appears to be eſſentially different in the ſeveral claſſes of animals. According to M. Brugnatelli, the gaſtric juice of birds of prey, and granivorous birds, is very bitter, and compoſed of a diſengaged acid, reſin, animal matter, and common ſalt; that of ruminating

ruminating quadrupeds is very aqueous, turbid, and ſalt, containing volatile alkali, an animal extract, and common ſalt. M. de Morveau, having digeſted portions of the internal tunic of the ſtomach in water, found that it has an acid character. M. Spallanzani thinks, that this character depends on the aliments, as he never found the acid juice in the ſtomach of carnivorous animals, but always in thoſe which feed on grain. M. Goſſe made the ſame obſervation on himſelf, after having uſed crude vegetables for a long time. It therefore appears, according to the opinion of M. Spallanzani, that the gaſtric juice, in its natural ſtate, is neither acid nor alkaline, or that, if it contains a peculiar acid, it is in the neutral ſtate. M. Brugnatelli thinks, that the white matter, in the excrements of carnivorous birds, contains phoſphoric acid; but M. de Morveau obſerves, that his experiments are not concluſive. M. Scopoli found ſal-ammoniac, and ſuſpects that the muriatic acid is produced by the vital power of animals; but no deciſive fact has been brought in ſupport of this opinion; every circumſtance, on the contrary, tending to ſhew, that this acid comes from the food.

Hence it may be concluded, 1. That the gaſtric juice is not yet well known; 2. That it appears to be different in the ſeveral claſſes of animals, and in the ſame animal, according

ing to the diverſity of food ; 3. That no proof has been brought to ſhew that it is a peculiar acid ; 4. That its moſt remarkable property conſiſts in its great ſolvent power, which extends even to bony and metallic ſubſtances ; an indifference, or want of preference between the matter it acts on, and eſpecially a very ſtrong antiſeptic quality, which it communicates to all the bodies it is mixed with, and which even puts a ſtop to putrefaction, in ſubſtances which have already began to be changed by that proceſs.

This laſt property has excited a greater degree of attention than the others. Meſſrs. Carmanati, Jurine, and Toggia, have applied the gaſtric juice on wounds. M. Carmanati has even uſed it internally ; and they all agree, with reſpect to its antiſeptic virtue. Time and experience muſt decide on the efficacy of this new remedy.

CHAP. XV.

Concerning the Humours, or Animal Matters, which have not yet been examined; ſuch as Sweat, the Naſal Mucus, the Cerumen, Tears, the Gum of the Eyes, the Seminal Fluid, and the Excrements.

THERE are many animal fluids and matters, which have not yet been examined. It is therefore not ſo much with a view to exhibit their properties, as to engage young phyſicians to make reſearches, equally new and uſeful, that we propoſe to ſpeak curſorily reſpecting the humour of tranſpiration, of ſweat, of the mucus of the noſtrils, the cerumen of the ears, the tears, the gummy matter of the eyes, the ſeminal fluid, and the excrements.

Phyſicians have diſcovered a great analogy between the fluid emitted by cutaneous tranſpiration and urine; they have obſerved, that theſe excretions mutually anſwer the ſame purpoſe in many circumſtances, and are therefore naturally led to conſider the vaporous fluid of tranſpiration, as of the ſame nature as urine. Medical practice has ſhewn, that

that its qualities are ſubject to variation; that its ſmell is faint, aromatic, alkaline, or ſour; that its conſiſtence is ſometimes glutinous, thick, tenacious, and that it leaves a reſidue on the ſkin; that it often tinges linen with various ſhades of yellow. M. Berthollet affirms, that ſweat reddens blue paper, and that this phenomenon takes place more particularly in parts affected with the gout. He thinks it contains the phoſphoric acid. It has been hitherto impoſſible to collect a ſufficiently large quantity of this excremental humour, to examine its properties with accuracy. Many inquiries, therefore, remain to be made, which can only be undertaken and purſued by phyſicians in peculiar circumſtances and occaſions.

The humour, prepared by the membrane of Schneider, which is thrown out of the noſtrils by ſneezing, deſerves to be carefully attended to by phyſicians. It is a kind of thick mucilage, white, or coloured, more or leſs fluid or conſiſtent in certain affections, and more eſpecially in catarrhs. No one has yet examined it.

The yellow, greeniſh, or brown matter, which is collected, and becomes thick, in the auditory canal, and is known by the name of wax, becauſe of its conſiſtence, has not been examined. It is very bitter, and appears to be of a reſinous nature; it ſometimes becomes ſo concrete, as to ſtop the

 auditory

auditory canal, and prevent the free paſſage of ſound: there ſeems to be ſome analogy between this and the inflammable matter of the bile.

No one has yet made experiments to diſcover the nature of tears, which are prepared in a peculiar gland, ſituated towards the external angle of the orbit, and deſtined by nature to maintain the humidity and ſuppleneſs of the external parts of the eye. This fluid is clear, limpid, and manifeſtly ſalt; it ſometimes iſſues out of the eye in large quantities. In the natural ſtate, it gradually flows into the noſtrils, and appears to dilute the mucus. Moſt authors who have ſpoken of this liquor, and in particular Pierre Petit, a phyſician of Paris, who publiſhed a treatiſe on Tears about the end of the laſt century, conſider them as water nearly pure. The gum, or humour, which adheres to the borders of the eye-lids, and appears to be ſeparated by the glands of Meibomius, is not better known than the tears.

Neither has the chemical nature of the ſeminal humour been more inquired into than that of the foregoing matters. The few obſervations, which it has been hitherto poſſible to make on this humour, have ſhewn, that it reſembles animal mucilages, becomes fluid by cold and by heat, and that the action of fire reduces it to a dry and friable ſubſtance.

The

The anatomical and microſcopical obſervations on this ſubject have been carried much further. They have ſhewn, that the ſeminal humour is an ocean, in which certain ſmall round bodies ſwim, which poſſeſs a rapid motion, and are by ſome conſidered as living animals, deſtined to reproduce the ſpecies, and by others as organic moleculæ, adapted to form a living being by their union. The microſcope, in the hands of a modern obſerver, has likewiſe ſhewn cryſtals formed in the ſeminal liquor by evaporation and cooling. It muſt be admitted, however, that theſe fine experiments have not hitherto been attended with conſequences which have advanced the ſciences, but that they have merely afforded data for the conſtruction of certain ingenious hypotheſes.

The food, by which animals are ſupported, contain a large quantity of matter, which is not capable of nouriſhing them, and is rejected out of the inteſtines in a ſolid form. The excrements are coloured by a portion of bile, which they carry with them. The fetid odour they exhale, ariſes from the commencement of putrefaction in their paſſage through the inteſtines. Homberg is the only chemiſt who has examined theſe matters. He obſerved, that the phlegm afforded by excrements diſtilled on the water-bath, was of a nauſeous ſmell; by waſhing and evaporation, he obtained a ſalt,

 which

which melted like nitre, and took fire in close vessels. The distillation of this matter in a retort, afforded the same products as other animal substances. Putrefied excrements afforded an oil without colour or smell, which did not convert mercury into silver, as he had been led to expect.

It must be observed, that the fecal matter examined by Homberg, was that of men, fed with coarse bread, and champaign wine; a circumstance which was said to be essential, in order to succeed in the alchemical experiments he was directed to make. There can be no doubt, but that the properties of the excrements must depend on the nature of the food, of which they are merely the residue.

CHAP. XVI.

Concerning Urine.

URINE is a transparent excrementitious fluid, of a citron yellow, a peculiar smell, and a saline taste, separated from the blood by two glandular organs, called kidneys, and from thence conveyed into a reservoir, which is universally known by the name of the bladder, and in which it remains

mains for a certain time. This fluid is a kind of lixivium, containing the acrid matters of the animal humours, which, if retained too long in the body, might be productive of miſchief and inconvenience. It is a ſolution of a great number of ſalts, and two peculiar extractive ſubſtances; and its quantity and quality varies according to circumſtances. The urine of man, which we propoſe to examine in particular, differs from that of quadrupeds; and the differences are ſtill more conſiderable between the other claſſes of animals. The ſtate of the ſtomach, and that of the fluids in particular, produce a great number of alterations, which cannot be aſcertained but by a long continued ſeries of experiments, few of which have yet been made. We ſhall therefore only ſpeak, in this place, of the urine of the human ſpecies in a healthy ſtate.

This fluid is diſtinguiſhed by phyſicians into two kinds; the one, called crude urine, when emitted a ſhort time after meals, is clear, and almoſt deſtitute of taſte and ſmell; it contains a much ſmaller proportion of the principles than the other, which is called urine of the blood, or urine of concoction.

This laſt is not emitted till the proceſs of digeſtion is finiſhed, and it is ſeparated from the blood by the kidneys; while the former appears to be filtrated, in part, from the ſtomach and inteſtines immediately to the bladder,

bladder, by means of the cellular membrane.

The ſtate of health, and eſpecially the diſpoſition of the nerves, have ſingular effects on the urine. After hyſteric or hypocondriac attacks, it flows in large quantities, and is without ſmell, taſte, or colour. The diſorders of the bones, and of the articulations, have likewiſe a great influence on this animal lixivium. It often depoſits a great quantity of matter, apparently earthy, but which ſeems to be a calcareous phoſphoric ſalt, as we ſhall hereafter obſerve. The urine of thoſe who have the gout is of this kind. Phyſicians, particularly Heriſſant and Morand, have obſerved, that when the bones are affected, or become ſoft, the urine depoſits a large quantity of this matter. It is likewiſe obſerved, that in the healthy ſtate, the urine contains a quantity of this matter, which is the baſis of bones, and was probably more than was required for the nutrition and reparation of thoſe organs.

Many foods are capable of communicating certain peculiar properties to urine. Turpentine produces a ſmell of violets, and aſparagus a very fetid ſmell, in this fluid. Such perſons as have weak ſtomachs, void urine, which retains the ſmell of ſuch foods as they have taken. Bread, garlick, onions, ſoup, and all vegetables, communicate their own proper ſmell to the urine.

From

From thefe facts, it follows that the urine exhibits phenomena, from which the phyfician may derive the greateft practical advantages. But it muft not be concluded, that a fimple infpection of the urine is fufficient to determine the nature of a diforder, the fex of the patient, and the remedies which are proper to be applied, as certain empirics pretend.

The human urine, confidered with refpect to its chemical properties, is a folution of a confiderable number of different fubftances. Some of thefe are falts, fimilar to thofe of minerals, and, as Macquer thinks, are derived from the foods, without having fuffered any alteration. Others are found to be analogous to the extractive principle of vegetables; and laftly, there are others which appear to be peculiar to animals, and even to urine, or which have not at leaft been found in confiderable quantities in the products of the other kingdoms, nor even in other animal fubftances, except urine. After having fhewn the method of extracting thefe feveral matters from urine, we fhall proceed to the hiftory of fuch as are peculiar to this fluid, and have not yet been defcribed.

Urine was formerly confidered as an alkaline liquor, or lixivium; but M. Berthollet has remarked, that it always contains an excefs of phofphoric acid, and reddens the tincture of turnfole. This phyfician has obferved,

obſerved, that the urine of gouty perſons contains leſs acid ſalt than that of perſons in perfect health; that during the fit of the gout, this fluid is much more acid than uſual, though not more ſo than the urine of a robuſt perſon. He conjectures, that in gouty patients the phoſphoric acid is not evacuated by urine, as in healthy perſons; that it wanders, as it were, and is carried into the articulations, where it excites irritation and pain. This exceſs of acid in the urine holds the calcareous phoſphat in ſolution.

M. Scheele ſeems to think, that this diſengaged acid of urine is not merely phoſphoric acid, but conſiſts of partly the ſame acid as he has diſcovered in the human calculus, and is called the lithiaſic acid by M. de Morveau. The latter acid, which is capable of concretion and cryſtallization, forms, according to the Swediſh chemiſt, the red cryſtals which are depoſited from urine, and alſo the brick-coloured precipitate, obſerved in the urine of ſuch as have fevers. The tophaceous concretions, in the articulations of gouty perſons, are likewiſe of the ſame nature as the calculus; that is to ſay, for the moſt part formed of the lithiaſic acid: hence we ſee, that M. Scheele does not agree in opinion with M. Berthollet. I ſhall give my thoughts on the ſubject in the hiſtory of the calculus of the bladder.

Freſh

Fresh urine, distilled in the water-bath, affords a large quantity of phlegm, which is neither acid nor alkaline, but quickly putrefies. As this phlegm contains nothing of value, the urine is commonly evaporated on a naked fire. In proportion as the water, which forms more than seven-eighths of this animal humour, is dissipated, the urine becomes of a brown colour; a pulverulent matter is separated, of an earthy appearance, which has been taken for selenite, but is a true salt of difficult solubility, and is composed of the phosphoric acid and lime, with a small excess of acid. This salt is of the same nature as the basis of bones, and is mixed with a small quantity of concrete lithiasic acid. When the urine has obtained the consistence of a clear syrup, it is filtrated, and set in a cool place; at the end of a certain time, saline crystals are deposited, which consist of marine salt, and two peculiar saline substances. These salts are known by the names of fusible salt, or native salt of urine: we shall examine their properties in the following chapter. Several successive products of these crystals are obtained, by repeated evaporations, at the same time that a certain quantity of marine and febrifuge salt crystallizes. When the urine affords no more saline matter, it is in the state of a very thick brown fluid, which is a kind of mother water, and holds in solution

ſolution two peculiar extractive ſubſtances. By evaporating it to the conſiſtence of a ſoft extract, and treating the reſidue with ſpirit of wine, Rouelle the younger has diſcovered, that a portion is diſſolved, and the other part remains untouched. He calls the firſt ſaponaceous matter, and the ſecond extractive matter.

The ſaponaceous ſubſtance is ſaline, and capable of cryſtallization. It is not dried without difficulty; and in this ſtate it attracts the moiſture of the air. By deſtructive diſtillation, it affords half its weight of ammoniacal chalk, a ſmall quantity of oil, and ammoniacal muriate. Its reſidue converts the ſyrup of violets to a green.

The extractive ſubſtance, ſoluble in water, and not in ſpirit of wine, is eaſily dried in the water-bath, like the extracts of plants; it is black, leſs deliqueſcent than the former, and affords, by diſtillation, all the products of animal matters. Such, according to Rouelle, are the characteriſtic properties which diſtinguiſh theſe two component parts of the extract of urine. We may likewiſe add, that this celebrated chemiſt obtained from one ounce to an ounce and a half of extract from a pint of urine, voided after concoction; whereas the ſame quantity of crude urine afforded no more than one, two, or three drachms.

If the extract of urine, inſtead of being ſepa-

ſeparated by ſpirit of wine, be diſtilled intire, it affords much ammoniacal chalk, a very fetid animal oil, ammoniacal muriate, and a ſmall quantity of phoſphorus: its coal contains a ſmall proportion of muriate of ſoda, or common ſalt. This analyſis of urine ſhews, therefore, that it is compoſed of a large quantity of water, the diſengaged phoſphoric and lithiaſic acids, muriate of ſoda, combinations of the phoſphoric acid with calcareous earth, mineral alkali, and volatile alkali, together with two peculiar extractive matters, which give the fluid its colour. As to the deep colour it acquires in many diſorders, and eſpecially in all bilious affections, I have diſcovered, that it is produced by the reſin of the bile, and that its extract, diſſolved by ſpirit of wine, is precipitated by water.

Urine when expoſed to the air, changes more quickly in proportion as the atmoſphere is hotter. Depoſitions are firſt formed by ſimple cooling; ſeveral ſaline matters cryſtallize at its ſurface and bottom, and frequently a reddiſh ſalt, which appears to be of the nature of the calculus. No one has obſerved the ſpontaneous changes of this excrementitious fluid but Mr. Halle, my aſſociate. He has diſtinguiſhed, in the decompoſition of urine left to itſelf, ſeveral terms, or periods, which afford ſediment, or cryſtals, of different natures, and are attended

tended with various changes. Our prefent purpofe not extending to the detail of all thefe changes, which are accurately defcribed in an excellent Memoir, inferted among thofe of the Royal Society of Medicine for the year 1779, we fhall confine ourfelves to the principal alterations to which it is fubject. Soon after it has become cold, its fmell changes, becomes ftronger, and indicates the prefence of volatile alkali; its colouring matter changes, and is feparated from the reft of the liquor; laftly, this alkaline fmell is diffipated, and is followed by another, lefs penetrating, but more difagreeable and naufeous; and the decompofition proceeds to its complete termination. Rouelle the younger has obferved, that crude and ferous urine does not putrefy fo quickly; that its fmell, after it has become changed, differs greatly from that of the urine of concoction; and laftly, that it becomes covered with mouldinefs, like the juices of vegetables, and folutions of animal jelly. Mr. Halle has obferved certain urines which became very acid before they paffed to the ftate of putrefaction. Urine, putrefied for a year, or more, affords fufible falt, as well as frefh urine; but it affords a much larger quantity of difengaged phofphoric acid, and effervefces with cretaceous volatile alkali. The putrefaction extricates and drives off a part of the volatile alkali. The falt depofited

ſited on the ſides of the veſſel during evaporation, is ſtrongly acid; and the quantity may be increaſed, by adding volatile alkali, according to the advice of Rouelle the younger.

Quick-lime, and dry fixed alkalis, immediately decompoſe the principles contained in urine. Nothing more is required, than to pour a ſolution of cauſtic, vegetable, or mineral alkali, into freſh urine, in order to produce an inſupportable putrid alkaline ſmell. This is produced by the decompoſition of the ammoniacal phoſphat. M. Berthollet has diſcovered, that lime-water, added to freſh urine, produces a precipitate, from which phoſphorus may be obtained. This phenomenon depends on the union of the lime with the exceſs of phoſphoric acid; and the precipitate conſiſts of, 1. The calcareous phoſphat, naturally contained in urine, and which was ſuſpended merely by the exceſs of phoſphoric acid; 2. An additional portion of calcareous phoſphat, formed by the union of the ſuperadded lime with the diſengaged acid. M. Berthollet, having obſerved that cauſtic volatile alkali likewiſe precipitates the calcareous phoſphat of urine, by neutralizing the diſengaged phoſphoric acid which held that ſalt in ſolution, remarks, that the weight of this precipitate, compared with that produced by lime-water, indicates the quantity of diſengaged

engaged phosphoric acid contained in the urine; because, in fact, the ammoniacal phosphat, formed in this experiment, remains dissolved; whereas the calcareous phosphat produced by lime-water, being insoluble, is precipitated at the same time as the other portion of calcareous phosphat, which naturally exists in the urine.

Acids have no action on fresh urine, but they quickly take away the smell of putrefied urine, and of the depositions it forms in that state.

Urine decomposes many metallic solutions. Lemery distinguished by the name of the rose-coloured precipitate, a magma of that colour, which is formed when the nitrous solution of mercury is poured into urine. This precipitate is partly formed by the muriatic acid, and partly by the phosphoric acid contained in this fluid. M. Brongniart has observed, that this preparation sometimes takes fire by friction, and burns rapidly on hot coals; he attributes this effect to a small portion of phosphorus.

Such is the present state of our knowledge respecting the chemical properties of urine. Much remains to be done, before we may esteem ourselves in possession of all that analysis is capable of discovering with regard to this fluid. It is necessary, for this purpose, to examine the different depositions observed

obſerved in urine, and well deſcribed by Mr. Halle, the red or tranſparent ſaline concretions which are formed, and which Mr. Scheele takes to be the lithiaſic acid; the abundant ſediment which urine affords after fits of the gout, in ſuch as are attacked by the ſtone, &c.

We ſhall now proceed to examine the peculiar ſaline products, obtained from urine, to whoſe properties it is very neceſſary to attend.

CHAP. XVII.

Concerning the Ammoniacal Phoſphat, the Phoſphat of Soda, and the Calculus in the Bladder.

WE have ſeen that urine contains many peculiar ſalts; theſe ſalts are combinations of the phoſphoric acid with volatile alkali, ſoda, and lime, and the baſe of the calculus of the bladder. We ſhall ſucceſſively examine theſe ſubſtances under the denominations given them by M. de Morveau, of ammoniacal phoſphat, phoſphat of ſoda, and lithiaſic acid. We ſhall deſcribe the properties of the calcareous phoſphat when we treat of bones.

The ſalt, obtained by the cooling of eva-

porated urine, has been called fuſible ſalt in general, becauſe it melts in the fire, as we ſhall preſently ſee; it has likewiſe been called eſſential ſalt of urine, or microcoſmic ſalt: in this firſt ſtate, it is far from being pure, but is contaminated by an extractive ſubſtance, together with marine ſalt and phoſphat of ſoda. Several chemiſts, Margraaf in particular, ſuppoſed that it was neceſſary, in order to avoid the mixture of marine ſalt, that the urine ſhould putrefy; they imagined, that the marine ſalt became converted into fuſible ſalt by the putrid action; a fact which is now known to be falſe. One hundred and twenty pounds of recent urine, afford, according to Margraaf, about four ounces of this ſalt, and two ounces of phoſphat of ſoda.

The accurate ſeparation of theſe two ſaline ſubſtances, which Shockwitz, le Mort, Boerhaave, Henkel, and Schloſſer, conſidered as one and the ſame ſalt, is not eaſy. To effect this, the uſual advice is to diſſolve the fuſible ſalt in hot water, evaporate the fluid, and cryſtallize it. But Rouelle the younger, and the Duc de Chaulnes, are the only chemiſts who have mentioned a very great and ſingular difficulty preſented in this proceſs. The greateſt part of the fuſible ſalt is diſſipated by the heat when the ſolution is evaporated; three-fourths being loſt by this means. The Duc de Chaulnes has deſcribed a pro-

cefs for purifying it with the leaft poffible lofs: it confifts in diffolving, filtering, and cooling this folution in well clofed veffels; in either cafe, a falt, cryftallized in very flat, rhomboidal four-fided prifms, is obtained, which is the ammoniacal phofphat; and above thefe firft cryftals, another falt, in cubes, or rather in long, fquare tablets, very different from the other, and which is the phofphat of foda: this laft may be feparated, according to the remark of Rouelle the younger, by removing its efflorefcence from the former, which does not change.

Ammoniacal phofphat, thus purified, and feparated from the phofphat of foda, has the form of very flat, rhomboidal tetrahedral prifms, as we have obferved, which are often truncated lengthwife on their acute edges, by which they become converted into a kind of hexagonal prifms; there are likewife found, according to Romé de Lifle, from whom the prefent defcription of this falt is taken, longitudinal fegments of thefe prifms, whofe longeft face refting on the veffel, has a rhomboidal form, and is interfected by two diagonal lines. The tetrahedral, and octahedral forms, attributed to this falt, are not met with, excepting when it contains marine falt and phofphat of foda; the muriate of foda appears more particularly to poffefs the property of modifying the form into that of an octahedron, fince marine falt, diffolved

in urine, and expoſed to the ſun, affords regular octahedrons at the end of ſome days. The taſte of this ſalt is at firſt cool, afterwards urinous, bitter, and penetrating; when placed on a burning coal, it ſwells, emits a ſmell of volatile alkali, and melts into a deliqueſcent globule, when urged by the blow-pipe. If diſtilled in a retort, very penetrating and cauſtic volatile alkali is diſengaged; the reſidue is a tranſparent glaſs, very fixed, and very fuſible, which attacks the glaſs of the retorts. Margraaf affirms, that it is ſoluble in two or three parts of diſtilled water, and preſents the characters of an acid. M. Rouelle affirms, that it is deliqueſcent. M. de Morveau, on the contrary, thinks that by means of heat it may be brought into the ſtate of a permanent glaſs. M. Prouſt has diſcovered, that this vitreous reſidue is a combination of the phoſphoric acid with a portion of a peculiar matter, which he did not appear to be acquainted with; but which, from the inquiries of ſeveral modern chemiſts, has been found to be phoſphat of ſoda. It muſt however be obſerved, that this compound glaſs is not obtained, excepting when ammoniacal phoſphat, which ſtill retains a portion of the phoſphat of ſoda, is diſtilled, and that in this caſe the glaſs appears to be always either opake, or very capable of be-

coming

coming ſo, while very pure ammoniacal phoſphat leaves a tranſparent glaſs.

The ammoniacal phoſphat is not changed by expoſure to air.

It is very ſoluble in water, no more than five or ſix parts of cold water being required to hold it in ſolution. Hot water, at the temperature of 170 degrees, decompoſes it, and even volatilizes a portion of its acid.

The ammoniacal phoſphat cauſes ſiliceous earth, clay, ponderous earth, magneſia, and lime, to enter into fuſion; but theſe vitreous compounds are effected by the phoſphoric acid, the volatile alkali itſelf being driven off.

Quick-lime, and the two pure fixed alkalis, decompoſe ammoniacal phoſphat, and ſeparate the volatile alkali: if lime-water be poured into a ſolution of this ſalt, a white precipitate is obtained, which conſiſts of calcareous phoſphat. The alkalis and all the cretaceous neutral ſalts decompoſe it likewiſe, and ſeparate the volatile alkali in the form of ammoniacal chalk.

The action of the mineral and the vegetable acids on ammoniacal phoſphat has not yet been ſufficiently examined. This action is referable to the various elective attractions which exiſt between the phoſphoric acid and its alkaline baſe: we ſhall treat of them when we come to ſpeak of that acid.

We ſhall likewiſe refer the alterations ammoniacal ſalt is ſuſceptible of, from metals and their calces, to the ſame part of our work, becauſe thoſe alterations abſolutely depend on the phoſphoric acid.

Ammoniacal phoſphat, treated with charcoal in cloſe veſſels, affords phoſphorus. Bergman has propoſed it as a flux in aſſays with the blow-pipe.

We have already deſcribed the method of obtaining the phoſphat of ſoda by itſelf; it will be proper, in this place, to mention the ſeveral dates of this diſcovery.

Hellot appears to be the firſt who ſpoke of it, in the year 1737, but he took it for ſelenite. Haupt mentioned it in 1740, under the name of ſal mirabile perlatum. Margraaf deſcribed it in the year 1745. Pott ſpoke of it in 1757; and, like Hellot, took it for ſelenite. Rouelle the younger examined it particularly in the year 1776, and called it fuſible ſalt, with baſe of natrum. All theſe chemiſts perceived the difference between this ſalt and the foregoing, to conſiſt more eſpecially in its not affording phoſphorus with charcoal; but Rouelle aſcertained its properties better than any other chemiſt; according to him, its cryſtals are flat, irregular, tetrahedral priſms, one of whoſe extremities is dihedral, and compoſed of two rhomboids, the other end adhered to the baſe. The four ſides of the ſolid, are

two

two alternate irregular pentagons, or two long rhombuſes.

The phoſphat of ſoda, or fuſible ſalt, with baſe of natrum, expoſed to the fire in a crucible, melts, and affords a white opake maſs; when heated in a retort, it gives out phlegm, without any character either of acid or alkali; its reſidue is a glaſs, or opake frit.

This ſalt effloreſces, and falls intirely into powder, by expoſure to air.

It readily diſſolves in diſtilled water, and cryſtallizes by evaporation; its ſolution converts the ſyrup of violets to a green.

Calcareous nitre decompoſes it, and affords a precipitate of calcareous phoſphat: the ſupernatant liquor affords a nitre of ſoda.

This ſalt is likewiſe decompoſed by the nitrous ſolution of mercury. It affords a white precipitate, which, diſtilled in a retort, produces a ſmall quantity of reddiſh ſublimate, with running mercury, and leaves at the bottom of the veſſel a white opake maſs, adhering to and combined with the glaſs. This mercurial precipitate, boiled with a ſolution of the ſalt of ſoda, forms again the fuſible ſalt with baſe of natrum, and leaves the mercury in the ſtate of a brick-duſt powder. All theſe facts were diſcovered by Rouelle the younger. M. Prouſt, at the inſtance of this celebrated chemiſt, whoſe pupil he was, made a conſiderable number of experiments, the principal reſults of which are the following.

The reſidue of phoſphorus, made with fuſible ſalt of the firſt cryſtallization, from which no more than one-eighth of ſalt of phoſphorus had been obtained, was lixiviated, and, by evaporation in the open air, afforded quadrangular cryſtals, of an inch in length, whoſe quantity, according to him, amounted to five or ſix drachms in the ounce of fuſible ſalt employed in making the phoſphorus. We muſt obſerve, that the quantity muſt be diminiſhed, on account of the water which enters into the cryſtals. This ſaline ſubſtance melts by fire into an opake glaſs; colours flame green; effloreſces in the air; decompoſes nitrous and marine ſalts, by diſengaging their acids; forms glaſſes with earthy matters in a melting heat, and ſaturates alkalis like an acid. From this examination, M. Prouſt thinks it different from all the ſaline ſubſtances known, that it was united with the phoſphoric acid and volatile alkali in the ammoniacal phoſphat, and that it formed with ſoda the fuſible ſalt with baſe of natrum, of Rouelle. He obſerved, that it acted as an acid, and compared it to ſedative ſalt; and with this idea M. Prouſt made new experiments on the fuſible ſalt of baſe of natrum, obtained by the proceſs of Rouelle before deſcribed.

According to him, lime decompoſes this ſalt, and has a ſtronger affinity with the opake ſubſtance, which ſerves the purpoſe of

of an acid, than with ſoda. If lime-water be poured into a ſolution of this ſalt, a precipitate is afforded, and the mineral alkali remains pure and cauſtic in the ſolution.

The mineral acids, and even diſtilled vinegar, decompoſe it by a contrary operation. Rouelle ſuppoſed that the vitriolic and nitrous acids did not act on this ſalt, becauſe they occaſion no apparent change; but M. Prouſt having mixed the vitriolic, nitrous, muriatic, and acetous acids, each ſeparately, with a ſolution of fuſible ſalt, with baſe of natrum, obſerved, that though no precipitate was afforded in theſe mixtures, the liquors by evaporation and cooling afforded vitriol and nitre of ſoda, marine ſalt, and the acetous ſalt of ſoda, which proves, 1. That this ſalt was decompoſed by the acids. 2. That it contains ſoda, as Rouelle the younger had ſhewn. As to the ſeparate ſubſtance which was before united to the mineral alkali, it is evident that it remains in ſolution in the fluids, at the ſame time with the newly formed neutral ſalts. M. Prouſt has obſerved, that after the mixture of vinegar, and the cryſtallization of the acetous ſalt of ſoda, if eight or ten times its weight of hot ſpirit of wine be poured into the mother water, the laſt portions of the neutral acetous ſalt were diſſolved, and a magma was formed, which he waſhed with new ſpirit of wine, and afterwards diſſolved

ſolved in diſtilled water. This ſolution of magma evaporated in the open air afforded cryſtals in quadrangular priſms, abſolutely ſimilar to thoſe obtained from waſhing the reſidue of phoſphorus made with the fuſible ſalt obtained in the firſt cryſtallization of urine. This peculiar ſubſtance therefore, which reſembles ſedative ſalt, according to M. Prouſt, ſaturates the ſoda in the fuſible ſalt with baſe of natrum. This diſcovery ſeems, in fact, to explain why it does not afford phoſphorus. To theſe details, M. Prouſt added, that this new ſubſtance always exiſting in the true fuſible ſalt, or ammoniacal phoſphat, communicated to the phoſphoric acid the property of melting into glaſs; for which reaſon I called it by the name of baſe of phoſphoric glaſs, in the firſt edition of this work; but M. de Morveau has ſince aſcertained, that the pure phoſphoric acid obtained by phoſphorus falling into deliqueſcence, and conſequently not containing this ſubſtance, melts alone by heat into a ſolid and permanent glaſs. The ſeries of experiments which M. Prouſt made with great care, and which is highly intereſting in its reſults, induced Bergman to conſider this ſubſtance as a peculiar acid, and he accordingly has given an account of it in the ſecond edition of his Diſſertation on the Elective Attractions, by the name of acid of ſal perlatum, acidum perlatum, doubtleſs from the

the denomination given by Haupt in the year 1740, to the fusible salt with base of natrum. M. de Morveau has since made it a particular article in his Dictionary of Chemistry, under the name of the ouretic acid, derived from the greek name of urine which affords it. But since the time of the experiments of M. Proust, the Dissertation of Bergman, and the writing of the article by M. de Morveau, M. Klaproth has published in Crell's Chemical Journal, an analysis of the fusible salt, with base of natrum, which destroys the existence of this pretended peculiar acid; and shews, that it is merely phosphoric acid combined with soda. M. Klaproth ascertained this fact by an experiment similar to that of Rouelle the younger; he precipitated the fusible salt with base of natrum, by calcareous, marine, or nitrous salt, the precipitate which Rouelle had before described as similar to the base of bones was found to afford phosphoric acid, by means of the vitriolic acid. M. Klaproth adds, that by saturating the phosphoric acid, obtained by the slow combustion of phosphorus with soda, even to a small excess, a salt absolutely similar to the sal perlatum of Haupt, or to the fusible salt with base of natrum of Rouelle, is obtained; and that in order to produce the substance described by M. Proust, nothing more is necessary than to deprive this salt of the excess of soda

ſoda by vinegar, or to add a ſmall quantity of phoſphoric acid. It is not therefore to be wondered at, after this diſcovery, that Bergman found abſolutely the ſame elective attractions in the perlate acid, and the phoſphoric acid. Theſe facts have been ſtated by M. de Morveau in a ſupplement to the mineral acids; and he obſerves, that after this diſcovery, no further queſtion will be made concerning either the ouretic acid or its ſalts.

It is very ſingular that the phoſphat of ſoda, or ſal perlatum, which after what has been ſaid, may properly be diſtinguiſhed by the former name, is not decompoſed by charcoal like the ammoniacal phoſphat, though this combuſtible ſubſtance deprives the phoſphoric acid of the baſe of vital air, or the oxyginous principle. The ſoda deprives this laſt acid of the property of being decompoſed by charcoal, though it does not act in the ſame manner on the vitriolic, or other acids. This is a ſtrong exception to the elective attractions of the oxyginous principle, and ſtands alone; it is equally remarkable, that the acid of phoſphorus added in exceſs to the phoſphat of ſoda, leaves this compound, which conſtitutes, according to M. Klaproth, the peculiar ſubſtance of M. Prouſt, the property of converting ſyrup of violets to a green. M. de Morveau adds to the hiſtory of phoſphat of ſoda, that when a ſolution of the muriate of lead is poured into a ſolution of this ſalt, a precipitate

pitate of phofphat of lead is afforded, which when diftilled with charcoal affords phofphorus, as M. Laumont, infpector of the mines has difcovered, with one of the ores of Huelgoet. Hence we may perceive, how the plumbum corneum propofed by Margraaf in the diftillation of phofphorus of urine may augment the quantity of the product, as we fhall explain in the following chapter.

The calculus or ftone which is formed in the human bladder, has long engaged the attention of phyficians and chemifts. Paracelfus, who gave it the barbarous name of duelech, fuppofed it to be formed by an animal refin, and compared it to arthritic concretions. Van Helmont confidered it as a concretion made by the falts of urine, and an earthy volatile fpirit; and fuppofed that it differed from the arthritic falt, which was caufed, according to him, by the thickening and acidification of the nutritive fluid. Boyle extracted from it oil, and much volatile falt. Boerhaave admits it to contain an earth united to volatile alkali. Hales obtained 645 times its volume of air, and out of 230 grains, the refidue was only 49; he called it animal tartar. Many learned phyficians, and efpecially Whytt and Deften, have confidered alkaline matters as the true folvent of the urinary calculus: many have even propofed foap lees, but their conclufions were not founded

founded on an accurate analyſis of the calculus. Meſſrs. Scheele and Bergman began this analyſis; they firſt diſcovered, that the ſtone in the bladder is formed for the moſt part of a peculiar acid, which M. de Morveau calls the lithiaſic acid: 70 grains of calculus affords by diſtillation 28 grains of this acid dry and ſublimed, ſome volatile alkali, and 12 grains of charcoal, very difficult to incinerate; 1000 grains of boiling water diſſolved 296 grains of the ſame acid. This ſolution reddened blue colours, but the greater part of the acid ſeparated by cooling in the form of ſmall cryſtals.

The concentrated vitriolic acid diſſolves the calculus by the aſſiſtance of heat, and becomes converted into ſulphureous acid. The muriatic acid does not attack it, the nitrous acid diſſolves it completely, nitrous gas and cretaceous acid being diſengaged during its action; this ſolution is red, and contains an acid at liberty; it dyes the ſkin, and other animal coverings of a red; no appearance of vitriolic acid is obſerved by the teſt of ſoluble ponderous ſalts, nor of lime by the ſaccharine acid. Lime-water forms a precipitate, ſoluble in acids without efferveſcence; cauſtic alkalis diſſolve the calculus, according to M. Scheele. Theſe ſolutions are precipitated by lime; 1000 grains of lime-water diſſolve 537, and the volatile alkali in great quantity likewiſe attacks the calculus. The ſame chemiſt affirms, that the

the brick-duſt coloured depoſition of the urine of ſuch as labour under fevers, is of the ſame nature. Though M. Scheele did not find lime in the ſtone of the bladder, Bergman obtained it by precipitating its nitrous ſolution by the vitriolic acid, and by calcining the reſidue of the ſame nitrous ſolution. Bergman has beſides diſcovered in the calculus, a white ſpongy matter, inſoluble in water, acids, and alkalis; the incinerated charcoal of this ſubſtance, whoſe quantity was too ſmall to permit him to aſcertain its nature, is not even ſoluble in the nitrous acid.

From the analyſis of theſe two celebrated chemiſts, which has been often repeated with the ſame reſults in the laboratory at Dijon, the calculus appears to be of the ſame nature as the earth of bones; yet Mr. Tennant, of the Royal Society of London, obſerved ſtones of the bladder which only loſt two-thirds by calcination, and whoſe reſidue melted into a glaſs, which became opake by cooling, and conſequently contained a very conſiderable quantity of calcareous phoſphat.

As to the lithiaſic acid, its properties, as far as they are at preſent known, 1. A concrête and cryſtalline form: 2. Difficult ſolubility in water; and in much larger quantity in hot than in cold water: 3. It changes the nature of the nitrous acid, part of whoſe oxyginous

oxyginous principle it abſorbs, and then forms a reddiſh deliqueſcent maſs, colouring many bodies: 4. It unites with earths and metallic calces, forming peculiar ſalts, which M. de Morveau calls lithiaſites of lime, of pot-aſh, of ſoda, of copper, &c.: 5. It prefers alkalis to earths: 6. It yields theſe baſes to the moſt feeble acids, even to that of chalk, which is the cauſe of the inſolubility of the calculus in cretaceous alkalis. This laſt character is peculiar to the preſent acid; however there remains, as M. de Morveau well obſerves, much to be done, reſpecting the lithiaſic acid; to which I may add, that it remains to be aſcertained whether it be not the modification of ſome other acid, as may be ſuſpected from the known reſemblance between the ſaccharine and oxaline acids, as well as between the pretended perlate or ouretic, and the phoſphoric acid.

M. de Morveau thinks, that the arthritic concretions, which phyſicians have ſuppoſed to be of the ſame nature as the calculus of the bladder, are very different from that ſubſtance; but he grounds his opinion only on certain experiments of Schenckius, Pinelli, and Whytt, which are far from poſſeſſing the accuracy at preſent required in experimental philoſophy; and the obſervations of Boerhaave, Frederick Hoffman, Springsfield, Alſton, Leger, &c. on the good

effects

effects of alkaline waters, ſoap, and lime-waters, on the arthritic and calculous affections, appear to me more proper to aſcertain the exiſtence of an analogy between theſe two kinds of concretions, than the former are capable of diſproving it. It muſt however, be allowed, as M. de Morveau obſerves, that experiment alone is ſufficient to decide the queſtion, which affords an additional proof of the great importance of chemical reſearches in the art of medicine, and the advantages it promiſes to that uſeful ſcience.

CHAP. XVIII.

Of the Phoſphorus of Kunckel.

PHOSPHORUS is one of the moſt combuſtible ſubſtances we are acquainted with. As it was originally obtained from urine, and the ſubſtance which affords it in the greateſt quantity, is the ammoniacal phoſphat, whoſe properties we have juſt examined, we think it proper to treat of the hiſtory of this ſubſtance in this place.

According to Leibnitz, the diſcovery of phoſphorus is due to an alchemiſt named Brandt, a citizen of Hamburg, who diſcovered it in 1667. Kunckel aſſociated with

a certain perſon named Krafft, to purchaſe this ſecret; but the latter having purchaſed it, and refuſing to communicate it to Kunckel, he reſolved to make a ſeries of experiments on urine, from which he knew it was extracted, in order to diſcover it. His inquiries were attended with ſucceſs, and therefore he ought to be regarded as the true inventor. Some perſons likewiſe attribute the honour of this diſcovery to Boyle, who in fact depoſited a ſmall quantity, in the year 1680, in the hands of the ſecretary of the Royal Society of London; but Stahl affirms that Krafft told him that he communicated the proceſs of making phoſphorus to Boyle: Boyle communicated his proceſs to a German, named Godfreid Hanckwitz, who had a good laboratory at London, and was for a long time the only perſon who made phoſphorus, and ſold it to all the philoſophers throughout Europe. Notwithſtanding a great number of receipts for making phoſphorus, and among others thoſe of Boyle, Krafft, Brandt, Hoffman, Teichmeyer, Frederic Hoffman, Neiwentyt, and Wadelius, have been publiſhed, ſince the year 1680, to the commencement of the preſent century, no chemiſt ſucceeded in preparing it; and the proceſs was in reality a ſecret, till a ſtranger, in the year 1737, offered at Paris to communicate a ſucceſsful method of making phoſphorus. The Academy nominated four chemiſts,

chemiſts, Hellot, Dufay, Geoffroy, and Duhamel, to attend this operation in the laboratory of the Royal Garden. The proceſs ſucceeded very well, the miniſter rewarded the foreigner, and M. Hellot deſcribed it very accurately, in a memoir inſerted among thoſe of the Academy for the year 1737. The operation conſiſts in evaporating five or ſix hogſheads of urine, till it is reduced into a granulated, hard, black, and ſhining ſubſtance; this reſidue is calcined in an iron pot, whoſe bottom is heated red-hot, till no more fumes ariſe, and a ſmell like that of peach bloſſoms is perceived; the calcined matter is lixiviated with about twice its weight of hot water, and is dried after the water has been decanted off. Three pounds of this matter are then mixed with one pound and a half of coarſe ſand, or pounded ſtone-ware, and four or five ounces of the powder of charcoal of beech. This mixture being moiſtened with half a pint of water, is introduced into a Heſſian retort; the matter is aſſayed, by making a portion red-hot in a crucible: if it emit a violet flame, with a ſmell of garlick, it is a proof that phoſphorus will be afforded. The retort is placed in a furnace built on purpoſe, and a large receiver is adapted, two-thirds full of water; the receiver muſt have a ſmall hole pierced in it; and M. Hellot conſiders this as one of the moſt neceſſary circumſtances

to inſure ſucceſs. Three or four days after the apparatus has been put together, a fire is made, ſo as very gradually to dry the furnace and the lutes. The fire is raiſed by degrees to the moſt extreme heat, and kept up in that ſtate for about twenty hours; the phoſphorus does not come over till about fourteen hours after the commencement of the operation, which in the whole laſts twenty-four hours. A large quantity of concrete volatile ſalt firſt riſes, which is partly diſſolved in the water of the receiver: the volatile, or aeriform phoſphorus, firſt paſſes in luminous vapours; the true phoſphorus next comes over, in the form of an oil, or reſembling melted wax. When no more paſſes over, the apparatus is left to cool for two days; the receiver is then unluted, and water is added to looſen the phoſphorus adhering to the ſides; the phoſphorus is then melted in boiling water, and cut into ſmall pieces, which are introduced into the necks of matraſſes, cut towards the middle of the body into the form of a funnel, and plunged in boiling water; the phoſphorus melts, is purified, and becomes tranſparent, by the ſeparation of a blackiſh matter, which riſes to the top; it is afterwards plunged in cold water, by which it is congealed, and is thruſt out of the necks of the matraſſes by a ſmall ſtick introduced at the leſſer end. Such, in ſhort, is the proceſs

cess described by Hellot. The length of the operation deterred chemists from repeating it, excepting Rouelle the elder, who performed it several times with success in his chemical lectures.

In the year 1743, Margraaf published, in the Memoirs of the Academy of Berlin, a new method of making a considerable quantity of phosphorus more readily than had been done before his time. According to his process, the plumbum corneum remaining after the distillation of four pounds of minium and two pounds of sal-ammoniac, is mixed with ten pounds of the extract of urine of the consistence of honey; half a pound of charcoal in powder being added, the mixture is dried in an iron pot till it is converted into a black powder; this powder is distilled in a retort, to obtain, by a gradual fire, the volatile alkali, fetid oil, and sal-ammoniac. Care must be taken to urge the fire no more than till the retort is moderately red. The black and friable matter of this distillation is that which affords the phosphorus; it is assayed by throwing a small quantity on heated coals; if it emits a smell of garlick, and a blue phosphoric flame, it is a proof that it has been well prepared. An earthen retort of Hesse or of Picardy, is filled to three-fourths of its capacity with this substance, well coated with lute; this vessel is placed in a reverberatory

furnace, with a dome and iron chimney of ſix or eight feet in height; a middle-ſized receiver, pierced with a ſmall perforation, and half filled with water, is to be adapted, and the place of junction muſt be luted with fat lute, covered with fillets dipped in white of egg and lime; a brick wall is built up between the furnace and the receiver, and the whole apparatus is then left to dry for a day or two. The diſtillation is then begun, by a fire very gradually raiſed, and the operation laſts from ſix, to eight or nine hours, according to the quantity of matter expoſed to diſtillation. The phoſphorus is rectified by re-diſtillation by a very gentle heat, in a retort of glaſs, with a receiver half filled with water. Moſt chemiſts have repeated the proceſs of Margraaf with ſucceſs; and it was the only proceſs uſed, till the late diſcovery of ſeparating the phoſphoric acid from bones, as we ſhall obſerve when we come to ſpeak of theſe organs.

It may be obſerved, that the proceſs of Margraaf differs from that of Hellot only in the addition of the plumbum corneum, and the dividing the operation into two; but the moſt valuable part of the operation of the learned chemiſt of Berlin, conſiſts in his determining which of the ſubſtances contained in urine ſerves to form the phoſphorus. By diſtillation of a mixture of the fuſible ſalt and charcoal, he obtained a very fine

fine phoſphorus, and obſerved that urine, from which this ſalt has been extracted, affords ſcarcely any of this combuſtible ſubſtance. It therefore follows, that phoſphorus is formed by means of one of the conſtituent parts of fuſible ſalt; and this ſubſtance is eaſily obtained, by diſtilling two parts of the glaſs obtained by this ſalt, decompoſed in a retort or a crucible, with one part of charcoal in powder. This operation requires much leſs time, and a leſs degree of heat, than thoſe we have before deſcribed, ſince, according to M. Prouſt, the phoſphorus comes over at the end of a quarter of an hour. It is doubtleſs the beſt proceſs for procuring the phoſphorus of urine; but ſeveral objections may be made to it: 1. The vitreous reſidue of the decompoſition of the ammoniacal phoſphat by fire, not being the pure phoſphoric acid, but combined with phoſphat of ſoda, which is not decompoſable by charcoal, the quantity of phoſphorus obtained by employing this reſidue is but very ſmall; ſince an ounce affords no more than a drachm, and frequently a leſs quantity. 2. Becauſe, when a large quantity of fuſible ſalt is obtained by evaporation and cooling, it is found to be mixed with a great quantity of the phoſphat of ſoda, which does not afford phoſphorus. It may from theſe two obſervations, be conceived why ſo ſmall a

quantity of this combuſtible ſubſtance is obtained by the diſtillation of fuſible ſalt with charcoal: fuſible ſalt alone, of the mixture of the ammoniacal phoſphat and phoſphat of ſoda, diſtilled with charcoal and muriate of lead, or plumbum corneum, may perhaps afford a larger quantity, ſince the latter appears to have the property of decompoſing phoſphat of ſoda.

Phoſphorus obtained by all the proceſſes we have deſcribed, is always the ſame ſubſtance. When very pure it is tranſparent, and of a conſiſtence reſembling that of wax; it cryſtallizes, by cooling, in laminæ, which are brilliant, and as it were micaceous; it melts in hot water, long before the fluid becomes boiling hot; it is very volatile, and by a gentle heat riſes and comes over in the form of a thick fluid. When in contact with air, it emits a fume from every part of its ſurface; and this vapour, which ſmells ſtrongly like garlick, appears white in the day-time, but is very luminous in the dark. The ſlow combuſtion of phoſphorus conſiſts in this diſengagement, and if it be left for a certain time expoſed to the air, it conſumes by degrees, and leaves a peculiar acid, whoſe properties we ſhall hereafter examine. This ſlow combuſtion cannot be performed, unleſs the phoſphorus be in contact with the air; and in order that it may be very luminous, a heat of from twelve

to

to fifteen degrees of Reaumur's thermometer, or about ſixty-three degrees of Fahrenheit's, is required, though it takes place at a lower temperature. The inflammation does not produce heat, nor ſet any combuſtible body on fire; but when phoſphorus is expoſed to a dry heat, of twenty-four degrees of Reaumur, or eighty-ſix of Fahrenheit, it takes fire with decrepitation, burns rapidly, with a very lively white flame, mixed with yellow and green, and deſtroys all the combuſtible bodies it touches with the greateſt facility. The vapours it emits are then very abundant, white, very luminous in the dark, and leave a different reſidue in each of theſe combuſtions: the firſt affords a liquor, which weighs more than twice as much as the phoſphorus made uſe of, and is known by the name of the phoſphoric acid: the ſecond leaves a thick matter, of a reddiſh white, which emits white vapours, till it has attracted a ſufficient quantity of the moiſture of the air to become fluid; it then reſembles the acid and fluid reſidue of the firſt combuſtion, or ſlow inflammation; yet theſe two acids preſent certain differences in their combinations, as Margraaf has obſerved, and as M. Sage has likewiſe pointed out, in the Memoirs of the Academy for the year 1777. We ſhall ſpeak more fully reſpecting theſe differences in the hiſtory of the phoſphoric acid.

The

The combuſtion of phoſphorus was conſidered by Stahl as the diſengagement of phlogiſton, which he ſuppoſed to be combined with the muriatic acid * in this inflammable ſubſtance. M. Lavoiſier, in order to diſcover what happens in this combuſtion, burned, by the concentrated rays of the ſun, phoſphorus under a glaſs veſſel, inverted over mercury; he obſerved that no more than a certain quantity can be burnt in a determinate bulk of air, and that this quantity conſiſts of one grain of phoſphorus for ſixteen or eighteen cubic inches of air; that after this combuſtion, the phoſphorus is extinguiſhed, and the air is no longer capable of burning new phoſphorus; that the volume of the air is diminiſhed, and the phoſphorus diſſipated in white ſnowy flakes, which adhere to the ſides of the veſſel. Theſe flakes are twice and a half the weight of the phoſphorus uſed, and this augmentation of weight correſponds exactly to that which the air has loſt, and depends intirely on the abſorption of the oxyginous principle by the phoſ-

* Stahl has affirmed in ſeveral of his works, that by combining the marine acid with phlogiſton, phoſphorus may be made. Margraaf made a ſeries of experiments with different combinations of the marine acid, treated with combuſtible bodies, and never ſucceeded in producing phoſphorus; he has likewiſe ſhewn, that the acid which remains after the combuſtion of this ſubſtance differs very much from that of marine ſalt; and this is at preſent univerſally admitted by all chemiſts. Note of the Author.

phoſphorus: in fact, the white flakes are the concrete phoſphoric acid, formed by the combination of phoſphorus with the portion of pure air contained in the atmoſpheric air, which has ſerved to burn this inflammable ſubſtance. This theory is the ſame as that of ſulphur, and it is therefore unneceſſary to repeat what has been ſaid reſpecting this ſubſtance in the mineral kingdom.

If phoſphorus be liquified in hot water, and vital air be paſſed through it under water, it burns, and is reduced to the ſtate of phoſphoric acid.

Though phoſphorus be not ſoluble in water, yet it is changed by it in proceſs of time, and loſes its tranſparency; becomes yellow, and covered with an efflореſcence and coloured powder; the water becomes acid, and appears luminous when agitated in the dark; the phoſphorus is therefore ſlowly decompoſed.

The cauſtic fixed alkalis diſſolve phoſphorus, by the aſſiſtance of a boiling heat; during this combination, a fetid gas, diſcovered by M. Gengembre, which has the ſingular property of taking fire and exploding, by the contact of atmoſpheric air, and ſtill more readily by the contact of vital air, is diſengaged: this elaſtic fluid conſiſts of phoſphorus diſſolved in inflammable gas.

The vitriolic acid, diſſolved with phoſphorus in a retort, decompoſes it almoſt intirely,

tirely, but without inflammation; the concentrated nitrous acid attacks it with violence, and ſuddenly inflames it. When this experiment is made in a retort, with nitrous acid not very concentrated, the phoſphorus burns by degrees, ſeizes the oxyginous principle of the nitrous acid, and forms the phoſphoric acid. This proceſs was deſcribed by M. Lavoiſier in 1780.

The muriatic acid, though ſuper-ſaturated with vital air, does not attack phoſphorus.

Nitrous ſalts inflame it with great rapidity, by the aſſiſtance of a low heat.

Sulphur and phoſphorus combine, according to Margraaf, by fuſion and diſtillation, and compoſe a ſolid ſubſtance, of an hepatic odour, which burns with a yellow flame, ſwells in water, to which it communicates acidity, and the ſmell of liver of ſulphur; properties which certainly ſhew a peculiar re-action between theſe two bodies.

Phoſphorus does not unite ſo readily with metals as ſulphur does, though it reſembles that ſubſtance in many of its properties. Margraaf attempted to make theſe combinations, by diſtilling the ſeveral metallic ſubſtances, each with two parts of phoſphorus: no peculiar phenomena were preſented but by arſenic, zink, and copper; all the other metals were not changed by the phoſphorus, which was partly burnt or ſub-

limed

limed in the receiver, without having experienced any remarkable change.

Phoſphorus, ſublimed with arſenic, afforded this celebrated chemiſt a ſubſtance of a beautiful red, ſimilar to realgar.

Zink, diſtilled twice ſucceſſively with this combuſtible ſubſtance, afforded yellow, pointed, and very light flowers; theſe flowers expoſed to the fire under a red-hot muffle, burned and afforded a tranſparent green glaſs, ſimilar to that of borax.

Copper, treated in the ſame manner with phoſphorus, loſt its brilliancy, and became very compact; its weight was increaſed ten grains in the half drachm, and it took fire, and burned, on being applied to a flame.

The Marquis de Bouillon and M. Sage have deſcribed a remarkable alteration which phoſphorus undergoes in metallic ſolutions: the firſt of theſe chemiſts has diſcovered, that ſmall ſticks of phoſphorus, plunged in ſolutions of gold, ſilver, copper, &c. became gradually covered with a kind of ſheath of ſhining metal: theſe valuable experiments ſhew that the phoſphorus has a ſtronger affinity with the oxyginous principle than many metals, and is capable of reducing their calces. Bergman has eſtabliſhed the fact, that the arſenical acid becomes black, and is converted to the ſtate of metallic arſenic, when heated with phoſphorus, which becomes phoſphoric acid, in proportion as it

it takes the oxyginous principle from the arſenic.

Phoſphorus diſſolves in all oils, and renders them luminous. Spielman has diſcovered that it diſſolves in ſpirit of wine, and that this ſolution emits ſparks when it is poured into water: part of the phoſphorus is precipitated in a white powder during this operation.

Phoſphorus is not yet uſed either in medicine or in the arts. Meſſrs. Menzies, Morgenſtern, Hartman, &c. affirm, that they have experienced very happy effects in malignant and bilious fevers, when the ſtrength has been exhauſted, and in the miliary fever; others have recommended it in the ſcarlet fever, the peripneumony, rheumatic pains, epilepſy, &c.; but though ſeveral diſſertations have already appeared in Germany on the medical virtues of phoſphorus employed internally, nothing can yet be eſtabliſhed concerning it, till experience has aſcertained its virtues with greater certainty.

CHAP. XIX.

Concerning the Phoſphoric Acid.

THE phoſphoric acid has been thus called, becauſe it has been thought to exiſt, ready formed, in phoſphorus, from which it was obtained by combuſtion; but M. Lavoiſier has proved, that this ſalt is a combination of phoſphorus with the baſe of pure air, or the oxyginous principle. To obtain this acid, four proceſſes may be uſed: the firſt conſiſts in burning phoſphorus rapidly, under glaſs veſſels filled with atmoſpheric air, inverted over mercury; the combuſtion being begun, either by a burning glaſs, or a red-hot iron wire; it is neceſſary firſt to moiſten the inſide of the glaſs with a ſmall quantity of water. This proceſs, directed by M. Lavoiſier, affords phoſphoric acid in a very ſhort time, but mixed with a ſmall quantity of phoſphorus, not decompoſed: vital air may be uſed for this combuſtion, but the inflammation is then ſo rapid and violent, that it often cauſes the glaſſes to fly in pieces. The ſecond proceſs, invented by Meſſrs. Wolfe and Pelletier, is performed by paſſing a current of vital air through phoſphorus melted

melted under water. In the third method, contrived by M. Lavoiſier, phoſphorus is burnt, by means of the nitrous acid, rather more than moderately ſtrong.

The fourth proceſs, or ſlow combuſtion, improperly called the formation of the phoſphoric acid per deliquium, is very well deſcribed by M. Sage. Sticks of phoſphorus are placed in a glaſs funnel, whoſe neck is received in a bottle, and its baſe covered, but not cloſely; a tube of glaſs is put into the neck of the funnel, in order to prevent the phoſphorus from falling through; and to give a paſſage to the air of the veſſel, diſplaced by the phoſphoric acid, care muſt be taken that the ſticks of phoſphorus do not touch each other, and that the temperature of the place does not exceed ſixty degrees; as without theſe precautions, the phoſphorus may deflagrate: by this method, an ounce of phoſphorus affords three ounces of an acid, which is collected in the bottle, with a ſmall quantity of water, added by a little at a time.

Theſe four proceſſes afford the phoſphoric acid in two different ſtates, accordingly as it contains phoſphorus not decompoſed, or intirely burnt, and ſaturated with the oxyginous principle. Theſe two acids exhibit phenomena, with reſpect to each other, ſimilar to thoſe exhibited by the vitriolic and ſulphureous acids: this is the reaſon of the

ſmall

ſmall difference between the reſults obtained by Meſſ. Sage and Lavoiſier, in the combinations of this acid, as related in the Memoirs of the Academy for 1777. They may be brought into the ſame ſtate of purity by diſtillation with ſpirit of wine, which takes away the portion of phoſphorus they may contain.

The phoſphoric acid, obtained by the ſlow combuſtion, contains but a very ſmall quantity of unburnt phoſphorus: it is a colourleſs fluid, without ſmell, of an acid taſte, and reddens the ſyrup of violets: when expoſed to the action of fire in a retort, pure phlegm comes over, the acid becomes concentrated, and heavier than even the vitriolic acid, and gradually grows ſolid, white, and ſoft, like an extract. Laſtly, when urged by a violent heat, it melts into a tranſparent, hard, very elaſtic and inſoluble glaſs, which no longer preſents the acid character, and is by M. de Morveau conſidered as a pure acidifiable baſe: but it is difficult to admit this opinion, becauſe vital air is not diſengaged during the fuſion. This ſolid and vitreous ſtate appears to depend on a more intimate combination between the acidifiable baſe and the oxyginous principle; and the want of acidity in this glaſs is no more to be wondered at, than the privation of its acid property, which the muriatic acid ſuffers by combination with an exceſs of the

 oxyginous

oxyginous principle. This idea reſpecting the more intimate fixation of the baſe of air in the acidifiable baſe of the phoſphoric acid, is confirmed by the difficulty of obtaining phoſphorus from it by the addition of charcoal, and by the neceſſity of giving a high temperature to the mixture for that purpoſe.

If the phoſphoric acid, obtained either by deflagration, or by the ſlow combuſtion of phoſphorus, be heated in an open veſſel, ſmall flames ariſe, from time to time, which doubtleſs are produced by a portion of phoſphorus not yet intirely burned. In theſe circumſtances, the acid becomes concentrated and dry, and at laſt melts, in the ſame manner as when treated in a cloſe veſſel.

The concentrated phoſphoric acid very quickly attracts the moiſture of the air; it unites to water with heat, combines with a great number of ſubſtances, and preſents peculiar phenomena in theſe combinations.

The phoſphoric acid does not appear to act on quartzoſe earth, neither by the dry nor the humid way, according to the experiments of Bergman and De Morveau; but it acts on glaſs, as appears from the experiments of Ingenhouſz and Prieſtley. When urged by the blow-pipe, together with clay, it boils; and the phoſphoric acid, melted in Heſſian crucibles, gives them a vitreous tranſparent glaze, as M. de Morveau remarks.

It unites with ponderous earth, and appears

pears to prefer it to all other baſes, except lime, according to Bergman's table of attractions. The properties of barytic phoſphat are not yet known.

The phoſphoric acid diſſolves cretaceous magneſia with effervescence; the ſalt it forms with this ſubſtance is of difficult ſolubility; a well ſaturated ſolution, after twenty-four hours repoſe, affords cryſtals in very ſlender, ſmall, flat needles, ſeveral lines in length, and obliquely cut off at each end; when expoſed to a gentle heat, they become reduced to powder: the vitriolic acid decompoſes this ſalt, according to Lavoiſier.

The phoſphoric acid, poured into lime-water, precipitates it in the form of a ſalt ſcarcely at all ſoluble, which does not effervesce with acids, and in which the acid is always predominant: this ſalt reddens blue paper, is decompoſed by the mineral acids, and even by the cauſtic fixed alkali, and affords, with the nitrous ſolution of ſilver, a precipitate of the colour of wine lees; and with that of mercury, a white pulverulent precipitate. This ſalt is of the ſame nature as the reſidue of burned bones. An exceſs of the phoſphoric acid renders the calcareous phoſphat ſoluble in water; but it is precipitated by magneſia, lime, cauſtic fixed alkali, and even by the volatile alkali, all which deprive it of its exceſs of acid. The calcareous phoſphat is not decompoſed by cauſtic alkalis, though it is by the ſame alkalis combined with fixed air.

The phoſphoric acid, ſaturated with vegetable alkali, forms a very ſoluble ſalt, which, by evaporation and cooling, affords tetrahedral cryſtals terminated by four-ſided pyramids, whoſe ſides correſpond with thoſe of the priſms: this phoſphat of pot-aſh is acid, and diſſolves much more completely in hot than in cold water; it expands on hot coals, and melts but with difficulty; when melted, it loſes its ſaline taſte; it precipitates the nitrous ſolution of ſilver, of a white colour, and that of mercury of a yellowiſh white: it is decompoſed by lime-water, which has a ſtronger affinity than the vegetable alkali to the phoſphoric acid.

The mineral alkali, united with the phoſphoric acid, produces a ſalt of an agreeable taſte, ſimilar to that of the muriate of ſoda, or common ſalt. The phoſphat of ſoda does not cryſtallize; it is reduced, by evaporation, into a gummy deliqueſcent matter, tenacious and adheſive, like turpentine. This ſalt was prepared by M. Lavoiſier, with the acid obtained by the deflagration of phoſphorus. M. Sage affirms that the ſalt prepared with the acid of phoſphorus, obtained by the ſlow combuſtion, and combined with ſoda, affords cryſtals which are not deliqueſcent.

Ammoniacal phoſphat, formed by the combination of the phoſphoric acid with the volatile

volatile alkali, is more ſoluble in hot water than in cold; and by cooling affords cryſtals, which, according to M. Lavoiſier, reſemble thoſe of alum. This ſalt muſt differ from that obtained from evaporated urine, becauſe the latter always contains a ſmall quantity of the phoſphat of ſoda.

The phoſphoric acid decompoſes the vitriolic, the nitrous, and the alkaline muriates, by the dry way, and diſengages their acids, by reaſon of its fixity; but it yields its baſes to them by the humid way.

The phoſphoric acid, in its fluid ſtate, acts only on a ſmall number of metallic ſubſtances: it readily diſſolves zink, iron, and copper; theſe ſolutions do not afford cryſtals by evaporation, except that of iron, which appears capable of cryſtallizing; the others are reduced into ductile and ſoft maſſes, reſembling extracts: if they be urged by heat, they throw out ſparks, and appear to form true phoſphorus. Margraaf and the academicians of Dijon have examined fully the action of this acid on metals and ſemi-metals.

The phoſphoric acid likewiſe precipitates certain metallic ſolutions; ſuch as thoſe of mercury, ſilver, and lead, by the nitrous acid.

This acid re-acts on oils, and exalts their ſmell; to ſuch oils as have no ſmell it gives

a ſweet and as it were ethereal ſmell; it thickens ſome oils.

When diſtilled from charcoal, in its dry ſtate, it affords phoſphorus.

When heated in a retort with ſpirit of wine, it afforded the academicians of Dijon a liquor ſtrongly acid, of a penetrating and diſagreeable ſmell, which burnt with a ſmall quantity of ſmoke, and exhibited ſome of the properties of ether. The phoſphoric acid was rendered volatile in this experiment, as appears from the acidity of the product. M. Lavoiſier has obſerved, that heat is produced in this mixture; yet moſt chemiſts conſider the phoſphoric acid as inſoluble in ſpirit of wine. Margraaf, Rouelle, Scheele, Wenzell, Laſſone, Cornette, and the Duc de Chaulnes, have directed the uſe of ſpirit of wine to purify and ſeparate the phoſphoric acid from the different foreign ſubſtances it may contain. Laſtly, the phoſphoric acid diſſolves the phoſphat of ſoda, forming with it a kind of triple ſalt, which by fuſion affords a hard, inſipid, inſoluble, non-deliqueſcent, and opake glaſs, ſimilar to that afforded by fuſible ſalt alone, when urged by the fire.

We muſt likewiſe obſerve, that the phoſphoric acid, which was formerly ſuppoſed to be peculiar to urine, exiſts in many animal matters, as we have already ſeen, and will hereafter be pointed out. Margraaf

diſcovered it in vegetables, and M. Berthollet has found it in all thoſe which afford volatile alkali by diſtillation. It has been found in many minerals, and in particular in lead and iron, in which it ſeems to have been afforded by the decompoſition of animal ſubſtances.

This acid has not yet been applied to any uſe; it might be, perhaps, medically uſed with ſucceſs, on account of its analogy with animal matters.

CHAP. XX.

Concerning the ſoft and white Parts of Animals and their Muſcles.

ALthough the analyſis of the ſolid parts of animals be leſs advanced than that of their fluids, yet we begin to acquire ſome knowledge of the different matters which compoſe them; it more eſpecially aſcertained that the difference between their texture or formation indicates a difference in their principles. This aſſertion will be confirmed by an examination of the ſoft and white parts, and alſo of the muſcles and bones.

All the ſoft and white parts of animals, ſuch

ſuch as the membranes, the tendons, the aponeuroſes, the cartilages, the ligaments, the ſkin, contain, in general, a mucilaginous ſubſtance very ſoluble in water, and not at all ſoluble in ſpirit of wine, which is known by the name of jelly. To extract this jelly, the animal parts muſt be boiled in water, and the decoction evaporated till it becomes a ſolid and tremulous maſs by cooling; a ſtronger degree of evaporation affords a dry, brittle, tranſparent ſubſtance, known by the name of glue.

Glue is prepared with all the white parts of animals; the ſkin, the cartilages, and the fat of oxen, are uſed to prepare the ſtrong glue of England, Flanders, Holland, &c. The ſkins of eels afford the baſe of gold ſize, and with old white leather gloves and parchment, a kind of glue uſed by painters, &c. is made. There are ſcarcely any animals, whoſe tendons, cartilages, nerves, and more eſpecially the ſkin, will not ſerve to prepare theſe different kinds of glue.

It muſt be here obſerved, that glues differ from each other in their conſiſtence, taſte, ſmell, and ſolubility: there are ſome which readily become ſoft in cold water, others are not diſſolved but in boiling water. The beſt glue is tranſparent, of a yellow browniſh colour, without ſmell and taſte, intirely ſoluble in water, with which it forms a viſcid uniform fluid that preſerves an equal degree

degree of tenacity and tranſparency in all its parts as it dries.

Animal jelly does not differ from glue properly ſo called, but in its poſſeſſing a leſs degree of conſiſtence and viſcidity. The firſt is more eſpecially obtained from the ſoft and white parts of young animals; it is likewiſe found in their fleſh, muſcles, ſkin, and bones. Glue is obtained only from animals of a greater age, whoſe fibres are ſtronger and drier. Theſe two ſubſtances however, exhibit the ſame chemical properties; and therefore we ſhall ſpeak of the jelly afforded by the cartilages or membranes of veal.

In its natural ſtate, jelly has no ſmell, and but a faint taſte: by diſtillation in the water-bath, it affords an inſipid and inodorous phlegm, capable of putrefaction; in proportion as it loſes its water, it aſſumes the conſiſtence of glue, and when intirely dried, it reſembles horn; when expoſed to a ſtronger fire, with acceſs of air, it ſwells, liquifies, and becomes black, emitting an abundant fume of a fetid ſmell; it does not take fire without difficulty; and by a violent heat by diſtillation in a retort, it affords an alkaline phlegm, an empyreumatic oil, and a ſmall quantity of ammoniacal chalk; it leaves a large maſs of charcoal, difficult to incinerate, which contains muriate of ſoda, and calcareous phoſphat.

Jelly,

Jelly, when expofed to a hot and moift air, becomes firft acid, and foon after putrid.

Water diffolves it in all proportions; acids, and efpecially alkalis, diffolve it readily; the nitrous acid difengages mephitis. Moft of thefe properties fhew a refemblance between jelly and the infipid vegetable mucilages, if we except thofe of affording volatile alkali by heat, and mephitis by the nitrous acid: and may not thefe laft be attributed to a portion of lymphatic matter or ferum, which the water extracts at the fame time with the gelatinous fubftance, efpecially when jellies or glues have been prepared by ftrong decoction long continued?

The mufcles of animals are formed of a parenchymatous and cellular fubftance, in which different humours are contained, partly concrete, and partly fluid. Thefe humours are compofed, 1. Of a red and white fluid. 2. Of a gelatinous mucilage. 3. Of a mild oil, of the nature of fat. 4. Of a peculiar extractive fubftance. 5. Laftly, of a faline matter, whofe nature is but little known. The analyfis of flefh, when diftilled in a water-bath, affords an infipid water; and in a retort an alkaline phlegm, an empyreumatic oil, and concrete volatile alkali; and which leaves a charcoal, from which a fmall quantity of fixed alkali, and febrifuge or marine falt, are obtained by incineration: thefe properties difcover

discover nothing which can be depended on respecting the nature of the principles. It is therefore necessary to have recourse to methods, by which these substances may be extracted without alteration, and afterwards examined separately.

M. Thouvenel, who first observed these different substances, forced out the fluids contained in the muscular spunge by pressure, coagulated the lymph by the action of heat, and obtained the salt by evaporation. He distilled and separated the gelatinous mucilage by means of water, and used spirit of wine to separate the salts and extract from the jelly. The accurate separation of these different matters is, in general, very difficult; because they are all soluble in water, and spirit of wine dissolves the saponaceous extract, and a part of the salt at the same time. The process which succeeds best, appears to be the following: The flesh is first washed in cold water, which takes up the colouring lymph with a part of the salt; the residue being digested in spirit of wine, gives out all the extractive matter, and a portion of salt to that menstruum. Lastly, the remaining mass being boiled in water, gives out its gelatinous part, and likewise those portions of extract and salt, which escaped the action of the former menstrua. By slowly evaporating the water first employed, without heat, the lymph coagulates, and is separated by the filter, and the

the ſaline matter may be obtained by a ſucceeding evaporation; the ſpirit of wine likewiſe being evaporated, affords the coloured extractive matter; and laſtly, the decoction affords the jelly and the fat oil which ſwims at the ſurface, and fixes by cooling. After the extraction of theſe different ſubſtances, nothing remains but the fibrous matter, which is white, inſipid, inſoluble in water, contracts and curls up by heat; and by diſtillation in a retort, affords much volatile alkali, and a very fetid oil. A large quantity of mephitis is obtained from this ſubſtance by the action of nitrous acid. In a word, it poſſeſſes the characters of the fibrous part of the blood; it therefore appears to be proved, that the muſcular organ is the reſervoir, in which the action of the vital powers depoſits the fibrous matter, which becomes concrete by reſt; and which appears to form the baſis of that animal property which phyſiologiſts call irritability.

Nothing remains now, but to examine the properties of each of the ſubſtances of which the fleſh of animals are compoſed, in order to aſcertain its nature with accuracy.

The lymph, the jelly, and the fat part are already known; the firſt perfectly reſembles the ſerum of blood. We muſt obſerve, that it is this ſubſtance, which coagulating by the heat of water, in which animal food is boiled, produces the ſcum which is carefully

carefully taken off. This ſcum is of a dirty red brown, becauſe the red lymph is altered by the heat of ebullition. The jelly extracted from fleſh cauſes ſoups, prepared with the fleſh of young animals, which contains it in greater quantities than that of older animals, to aſſume the form of a tremulous maſs. It is abſolutely ſimilar to that which conſtitutes the ſoft and white parts of animals, whoſe properties have been explained in the preceding article. The fat ſubſtance which forms the flat and round drops that float on the ſurface of broths and ſoups, and become ſolid by cooling, has all the characters of greaſe. It only remains, therefore, to examine the extractive matter, and the ſolid, obtained in the analyſis of the muſcles.

That which M. Thouvenel calls the mucous extractive ſubſtance, is ſoluble in water, and ſpirit of wine; it has a ſtrong taſte, whereas jelly has none. When it is very concentrated, it is acrid and bitter; and it has a peculiar aromatic ſmell, which fire developes. This ſubſtance gives the colour to ſoups, as well as the taſte and agreeable ſmell which are well known. When they are too much evaporated, or the quantity of fleſh is very conſiderable in proportion to the water, ſoups are high coloured, and more or leſs acrid. The action of fire developes and exalts the taſte of this extractive ſubſtance, ſo as even to give it the taſte of ſugar, or

or caramel, as is obſerved on the ſurface of roaſt meat, which is commonly called the brown. If we further examine the properties of this extractive ſubſtance when evaporated to dryneſs, we obſerve, that its taſte is acrid, bitter, and ſaline; that it ſwells and liquifies on hot coals, emitting a penetrating acid ſmell, ſimilar to that of burnt ſugar; that it attracts moiſture when expoſed to the air, and acquires a ſaline efflorescence on its ſurface; that it becomes ſour, and putrefies in a warm air, when diluted with a certain quantity of water; and laſtly, that it is ſoluble in ſpirit of wine. All theſe characters indicate a reſemblance between this acid and the ſaponaceous extracts, and ſaccharine matter of vegetables.

The nature of the ſalt which cryſtallizes in the ſlow evaporation of the decoction of fleſh, is not yet perfectly known. M. Thouvenel obtained it in the form of down, and that of irregular cryſtals. This chemiſt thinks that it is a perfectly neutral ſalt, conſiſting of pot-aſh, and an acid which has the character of the phoſphoric acid in frugivorous quadrupeds, and that of the muriatic acid in carnivorous reptiles. Though this ſalt may be conſidered as unknown, till a ſufficient quantity ſhall have been collected, to admit of its being examined with accuracy; yet it is very probable that it conſiſts of the phoſphoric acid, combined with the mineral

and

and vegetable alkali, and mixed with calcareous phoſphat. Theſe ſalts are indicated even with exceſs of acid, as in urine, by the teſt of lime-water and volatile alkali, which form white precipitates in the decoction; and the nitrous ſolution of mercury, which affords a roſe-coloured precipitate with the ſame liquor.

We may likewiſe add, that the moſt abundant ſubſtance, and that which conſtitutes the proper character of muſcular fleſh, is the fibrous part. This matter is depoſited by the blood, which contains it in a large proportion, and appears to be of great importance in the animal economy. Its nature and properties have not been ſufficiently attended to in phyſiological inquiries reſpecting the quantity and weight of muſcular fleſh compared with the other organs. The characters which diſtinguiſh this animal matter are, 1. That it is not ſoluble in water. 2. It affords a larger quantity of mephitis by the nitrous acid, than any other ſubſtance. 3. It afterwards affords the ſaccharine acid, and that which M. de Morveau calls the maluſian acid. 4. It quickly putrefies when moiſtened, and affords much concrete volatile alkali by diſtillation.

Theſe properties ſhew, that it is formed by a fat or oily ſubſtance combined with mephitis, together with the phoſphat of ſoda, and the calcareous phoſphat, which are

are ſeparated by the action of the nitrous acid. I have conſidered the purpoſes which are anſwered in the animal economy by this fibrous matter, in a particular Memoir inſerted among thoſe of the Royal Society of Medicine.

CHAP. XXI.

Concerning the Bones of Animals.

THE bones are the ſupport of all the other organs of animals, the baſes on which all the ſoft parts reſt. Theſe hard ſubſtances cannot be conſidered as paſſive in the animal economy, they are true ſecretory organs, which ſeparate from the blood and other humours a peculiar ſaline ſubſtance, of which they are the reſervoir, or place of depoſition.

The bones in all animals, from man to inſects and worms, differ in their texture, ſolidity, relative poſition, and probably in their nature. Chemical analyſis has not yet decided reſpecting this laſt point; but it can hardly be ſuppoſed, that the bones of men and quadrupeds are of the ſame nature as the ſoft; and flexible bones of fiſhes, reptiles, and more eſpecially the corneous coverings of

of insects, as well as the calcareous shells of reptiles.

The general view which we shall here take of the bones of animals, does not permit us to dwell on such differences as chemists have not yet sufficiently ascertained by experimental inquiry. The bones of men and of quadrupeds, which alone have been hitherto examined by chemists, are not earthy matters, as was formerly supposed: they contain a certain quantity of gelatinous matter, dispersed in small cavities, formed by the interval between the solid parts which compose their texture; and the solid parts themselves, though they seem to resemble earthy substances by their insolubility and firmness, have been for several years past acknowledged to be a true neutral salt, consisting of phosphoric acid and lime.

Bones exposed to fire with the contact of air, quickly take fire, by virtue of a certain quantity of medullary fat which they contain. By distillation in a retort, they afford an alkaline phlegm, a fetid empyreumatic oil, and much concrete volatile alkali: their coal is compact, and difficultly incinerated, and leaves a white residue, which, by washing in cold water, affords a small quantity of cretaceous soda; hot water afterwards takes up a certain quantity of selenite: the residue of these lixivia is insoluble in water, and is the

the calcareous phoſphat diſcovered by M. Gahn of Stockholm, in 1769. Bones calcined in a furnace in the midſt of the charcoal, remain luminous in the dark: by a ſtrong heat they are ſemi-vitrified and reduced into a hard very white kind of porcelain.

Water, in which bones, reduced into ſmall pieces or raſped, are boiled, becomes loaded with a ſubſtance which renders it viſcid, and is a true gelatinous matter.

The cretaceous alkalies decompoſe the calcareous phoſphat, which forms the baſe of bones. This decompoſition was diſcovered by the chemiſts of the academy of Dijon: they inform us, that they produced it by fuſing a mixture of the powder of calcined bones, and cretaceous vegetable alkali.

Acids act on bones, and decompoſe the calcareous phoſphat they contain; by which means it was that Scheele, in the year 1771, ſucceeded in preparing phoſphorus with bones. This chemiſt diſſolved bones in the nitrous acid, which ſeized the lime, and formed calcareous nitre; the ſalt remaining in ſolution, together with the diſengaged phoſphoric acid: on this mixture he poured vitriolic acid, which ſeizing the lime of the calcareous nitre formed ſelenite; this ſalt being precipitated on account of its inſolubility, was ſeparated by the filter. Laſtly, he diſtilled

diſtilled in a retort the filtered liquor containing the nitrous and phoſphoric acids, and when the latter by the evaporation was reduced to the conſiſtence of ſyrup, he mixed it with charcoal, to obtain phoſphorus. Meſſrs. Rouelle, Poulletier, de la Salle, and Macquer, were the firſt who repeated theſe valuable experiments at Paris. Laſtly, the Academicians of Dijon, Meſſrs. Rouelle, Prouſt, and Nicolas de Nancy, communicated their inquiries and proceſſes. Many other chemiſts have examined the ſeveral ſolid ſubſtances, and among the latter Mr. Bernierd obtained phoſphoric acid from foſſil bones, from the bones of the whale, the elephant, the porpoiſe, the elk, the ox, the teeth of the ſea cow, and the human ſpecies, and the grinders of the elephant; and he obſerved that all theſe bones afforded the ſame ſubſtances, and contained phoſphoric acid in different quantities. The Marquis de Bullion has likewiſe obtained phoſphoric glaſs from ivory, and from the bones of fiſhes.

The proceſs of the chemiſts of Dijon and of M. Nicholas is at preſent moſtly uſed to obtain the phoſphoric acid from bones: the bones are calcined to whiteneſs, reduced to powder, ſifted and mixed in a ſtone-ware pan, with an equal portion of oil of vitriol, a ſufficient quantity of water being added, to give the whole the conſiſtence of clear ſoup; this mixture being left at reſt for ſeveral hours, grows

grows thick; it is then poured on a filter of double cloth, and washed with water, till the fluid which passes through is tasteless, and no longer precipitates lime-water; in this case it is certain, that the residue contains no more disengaged phosphoric acid: the filtered water being evaporated deposits gradually a white substance which is selenite, and must be separated by a filtration, care being taken to wash it with a sufficient quantity of water to carry off the phosphoric acid that may adhere to it. These filtrations are to be repeated till the fluid deposits no more precipitate: it is then evaporated to the consistence of honey, or a soft extract, and at that time has a brown colour and greasy aspect. If this be gradually heated in a crucible till it ceases to emit a sulphureous, and as it were aromatic smell, and no longer boils, it acquires a semi-vitreous consistence with an acid taste, and attracts the humidity of the air: a greater degree of heat fuses it into a transparent, hard, insipid, insoluble matter, which has no acidity. When phosphorus is intended to be made, it is not necessary to continue the heat till the residue becomes converted into the form of an insoluble glass, because it then would not afford phosphorus, but by a strong heat and much less readily, than while it is still soft and deliquescent. To convert it into phosphorus

phoſphorus it is pulverized, mixed with one third of its weight of very dry charcoal, and the mixture introduced into an earthen retort, to which a receiver half filled with water, and pierced with a ſmall aperture, or terminating in a ſyphon connected by the apparatus of Woulfe is adapted; the fire is raiſed by degrees till the retort is heated to whiteneſs, at which time the phoſphorus paſſes over in drops, and the operation laſts in the whole from five to ſeven or eight hours, according to the quantity of the matter diſtilled, and the heat the furnace is capable of giving. From ſix pounds of bones, twenty ounces, or a little more, of the vitriform reſidue is uſually obtained; and this reſidue affords about three ounces of very good phoſphorus, and a few drachms of phoſphorus half decompoſed.*

* It is not neceſſary, for the making of phoſphorus, to carry the evaporation further than till the matter has acquired the conſiſtence of ſyrup, which may be conveniently performed in a copper veſſel; and inſtead of a receiver, the neck of the retort may be plunged ſimply in water contained in an open baſon. Care muſt be taken that the neck of the retort is not plunged ſo deep as that the water may riſe into the body of the veſſel, when abſorption takes place, but that the fluid in the baſon may by its fall ſuffer air to enter; in this caſe a ſmall quantity of the phoſphorus within the neck of the retort may be burned, but the quantity thus loſt is very inconſiderable. Phoſphorus is uſually purified by ſtraining it through a leather bag immerſed in hot water; but the beſt method of clearing phoſphorus from the impurities of the firſt diſtillation, is to re-diſtil it with a very gentle heat. T.

This product obtained from bones by the vitriolic acid, as well as the residue of the ammoniacal phosphat, decomposed by fire, does not consist of the pure phosphoric acid, since it affords at most one-fifth of its weight of phosphorus: it appears to contain a certain quantity of phosphat of soda. If this salt remains mixed with calcareous phosphat, arising from a small quantity of selenite, it usually melts with the phosphat, and forms a very hard opake glass, which resists the action of all menstrua.

M. de Morveau has proposed a method of obtaining very pure ammoniacal phosphat, with the phosphoric acid of bones; for this purpose, calcined bones must be dissolved in the diluted vitriolic acid, and the solution essayed by that of bones in the nitrous acid, in order to be sure that no disengaged vitriolic acid remains, the portion of calcareous phosphat it contains is precipitated by the caustic volatile alkali, as M. Wiegleb practises in his process; after which the liquid is filtrated, and suffered to evaporate spontaneously. Very beautiful crystals of ammoniacal phosphat are obtained, mixed with a small quantity of phosphat of soda, which separates by efflorescence. The calcareous phosphat, which remains on the filter, may be decomposed for the making of phosphorus.

CHAP.

C H A P. XXII.

Concerning different Subſtances uſed in Medicine and the Arts, which are obtained from Quadrupeds, Cetaceous Animals, Birds, and Fiſhes.

IF we propoſed to make an accurate and ample hiſtory of all the ſubſtances afforded by animals, and applied to medical purpoſes, or uſed in the arts, it would occupy more of our time than has already been applied to the animal kingdom, more eſpecially if we were to treat of the ſeveral animal matters, which empiriciſm, or ignorant credulity, have formerly introduced into medicine as celebrated remedies, but which at preſent are regarded as intirely uſeleſs. We do not, however, propoſe to mention more than the principal of theſe ſubſtances, which medical and chemical experience has ſhewn to poſſeſs valuable properties, or which are of the greateſt utility in the arts.

Among the matters afforded by quadrupeds, we ſelect caſtoreum, muſk, and hartſhorn. The white ſubſtance produced by a cetaceous animal, and known by the name of ſpermaceti, will be treated of apart.

Among the products of birds, we ſhall exhibit the analyſis of eggs; among oviparous quadrupeds and ſerpents, the tortoiſe, the frog, and the viper will claim a ſeparate article. Icthyocolla, or iſinglaſs, is the only product of fiſhes which we ſhall conſider. The claſs of inſects will afford a greater number of objects: cantharides, ants, millipedes, honey, wax, the ſilk worm, and ſilk, gum lac, kermes, cochineal, and crabs eyes; and laſtly, we ſhall conclude our examination of the products of the animal kingdom, by thoſe of coral and corallines, which belong to the claſs of worms and polypi.

From this ſhort enumeration, it will be ſeen, that we paſs over in ſilence a great number of other matters, formerly uſed in medicine; ſuch are, among others, ivory, unicornu, the teeth of the hippopatamus, of the beaver, of the boar, the bones of a ſtag's heart, the feet of the elk, bezoar, civet, and the blood of the wild goat, among quadrupeds; the ſwallow's neſt, gooſe greaſe, peacock's dung, and the membrane of the ſtomach of poultry, among birds; the toad, and the ſcincus among oviparous quadrupeds; the gall and ſtones of carp, the liver of the eel, the ſtones of perch, the jaws of the pike, among fiſhes; the ſcarabæus, ſpider's-web, the meloe, or proſcarabæus, and the claws of crabs among inſects. Laſtly, ſhell-worms, ſnails, oyſter-ſhells, nacres of pearl,

and bones of cuttle-fiſh, among the naked, or covered worms. Among all theſe ſubſtances, ſome have only imaginary virtues, and others are well ſupplied by thoſe we have choſen, and which we ſhall proceed to examine.

I. The name of caſtoreum is given to two bags, ſituated in the inguinal region of the male or female beaver, which contains a very odorous ſubſtance, ſoft and almoſt fluid when recently cut from the animal, but which dries, and aſſumes a reſinous confiſtence, in proceſs of time. This ſubſtance has an acrid, bitter, and nauſeous taſte; its ſmell is ſtrong, aromatic, and even fetid; it conſiſts of a coloured, reſinous matter, ſoluble in ſpirit of wine or ether, together with a gelatinous mucilage, and an extractive part taken up by water, and a ſolid, which cryſtallizes in the aqueous ſolution by evaporation, but whoſe nature has not yet been examined. The reſin of caſtoreum, in which its whole virtue reſides, appears to be analogous to that of bile. All the ſubſtance of this animal product is incloſed in membranous cellules, which proceed from the internal tunic of the bag which contains them. The caſtoreum has not yet been accurately analyzed; it is only aſcertained, that it affords a ſmall quantity of eſſential oil and volatile alkali by diſtillation, and that the ſeveral matters of which it is com-

poſed

posed may be separated by means of ether, spirit of wine, and water.

It is medicinally used as a powerful antispasmodic in hysterical and hypochondriac affections, and the convulsions which are caused by those affections: it often produces the most speedy and happy effects, but it sometimes happens that it irritates instead of calming, according to the disposition of the nerves and sensible system; it must for this reason be administered at first only in small doses: it has likewise been successfully administered in the epilepsy and tetanus. The dose is from a few grains to half a drachm in substance; it enters into the composition of boles, and is often united, almost always advantageously, with opium, and the sedative or narcotic extracts; its spirituous and etherial tinctures are likewise used, from a few drops to twenty-four or thirty-six grains, in proper liquids.

II. Musk is a substance, whose strong and permanent smell is universally known; it is contained in a bag placed near the umbilical region of a ruminating quadruped, resembling the antelope, from which it does not differ sufficiently to form a particular genus. This substance resembles castoreum in its chemical properties; it consists of a resin, united to a certain quantity of mucilage, bitter extract, and salt; it is often falsified; its virtues are stronger

ſtronger than thoſe of caſtoreum; and on account of its greater activity, it is uſed only in caſes of imminent danger. It is preſcribed as a powerful antiſpaſmodic in convulſive diſorders, the hydrophobia, &c.; and is likewiſe conſidered as a violent aphrodiſiac. It muſt be uſed with great caution, becauſe it often excites nervous affections, inſtead of mitigating them.

III. Hartſhorn is an animal ſubſtance which is very frequently uſed in medicine; it is a bony ſubſtance, and does not in any reſpect differ from other bones; it contains abundance of taſteleſs jelly, very light, and nouriſhing, which is extracted by boiling the ſubſtance, reduced into ſmall pieces, in eight or ten times its weight of water. When diſtilled in a retort, it affords a reddiſh and alkaline phlegm, called volatile ſpirit of hartſhorn; an oil, more or leſs empyreumatic; and a large quantity of ammoniacal chalk, contaminated by a ſmall quantity of oil; a prodigious quantity of gas is diſengaged, for the moſt part inflammable. As the volatile ſalt is coloured, it is neceſſary to digeſt it in a ſmall quantity of ſpirit of wine, which takes away the colouring oil. The carbonaceous reſidue being incinerated, is found to contain a ſmall quantity of natrum, ſelenite, and much calcareous phoſphat, mixed with phoſphat of ſoda, which may be decompoſed

posed by oil of vitriol, in the manner already described in treating of bones.

The spirit and the salt of hartshorn are used in medicine as good antispasmodics; the first, saturated with the acid salt of amber, forms the fluid called succinated spirit of hartshorn.

The oil of hartshorn, rectified by a gentle heat, becomes very white, odorous, volatile, and almost as inflammable as ether; it is known by the name of the animal oil of Dippel, a German chemist, who first prepared it. A great number of rectifications were formerly made to obtain this oil very white and fluid; but it has since been discovered, that two or three distillations are sufficient, provided care be taken, 1. To introduce the oil into the retort, by means of a long funnel, in order that the neck of this vessel may be very clean, as a single drop of the coloured oil is sufficient to give a tinge to all that comes over. 2. To take only the first most volatile and whitest portions. We are indebted to Messrs. Model and Baumé for these observations. Rouelle has likewise given a very good process for obtaining this oil: it consists in distilling it with water: and as there is only the most volatile and truly ethereal part contained in the oil of the first distillation, which is capable of rising at the degree of heat of boiling water, this method is attended with a certainty of the most attenuated and penetrating

ing portion coming over alone. The animal oil of Dippel has a lively ſmell, and a ſingular degree of lightneſs and volatility, and exhibits all the properties of vegetable eſſential oils, and from which does not appear to differ, but in containing the volatile alkali, as appears by its converting ſyrup of violets to a green, according to the obſervation of M. Parmentier. This oil is uſed in drops, in nervous affections, the epilepſy, &c.

IV. The white ſubſtance, improperly called ſpermaceti, is an oily, concrete, cryſtalline, ſemi-tranſparent matter, taken out of the cavity of the cranium of the cachalot; it is purified by liquefaction, and the ſeparation of another fluid and inconcreſcible oil, with which it is mixed. This ſubſtance exhibits very ſingular chemical properties; for it reſembles fat oils in ſome reſpects, and eſſential oils in others.

Spermaceti heated with the contact of air takes fire, and burns uniformly without emitting any diſagreeable ſmell. It is therefore made into beautiful candles at Bayonne, at St. Jean de Luz, &c.

When diſtilled by a naked fire, it does not afford an acid phlegm like fat oils, as M. Thouvenel has obſerved, but it paſſes intirely, and almoſt without alteration, into the receiver, as ſoon as it begins to boil, and leaves a coaly mark in the retort. By repeating this operation,

operation, it loſes its ſolid form, and remains fluid without becoming more volatile.

Spermaceti expoſed to a hot air, becomes yellow and rancid, but leſs readily than the other concrete fat oils. The water in which it is boiled affords only a light mucilaginous unctuous reſidue.

The cauſtic alkali diſſolves ſpermaceti, and forms a ſoap which gradually beeomes ſolid, and even friable.

The nitrous and marine acids have no action on it. The concentrated vitriolic acid diſſolves it, and alters its colour. This ſolution is precipitated by water, like the oil of camphor.

Spermaceti unites with ſulphur like the fat oils.

The fat and eſſential oils diſſolve ſpermaceti by the aſſiſtance of heat; hot ſpirit of wine likewiſe diſſolves it, and ſuffers it to precipitate by cooling. Ether effects this ſolution in the cold, or by the ſimple heat of hand.

Has not ſpermaceti the ſame relation to fat oils, as camphor to eſſential oils?

This ſubſtance was formerly much uſed in medicine, a great number of virtues having been attributed to it; it was more particularly uſed in catarrhs, ulcers of the lungs, of the reins, &c. It is not at preſent uſed except as a ſoftening remedy, and then in ſmall doſes, mixed with mucilages, becauſe it is found

to

to lie heavy on the ſtomach, occaſioning nauſea, and even vomiting.

I have found in animal matters, and particularly in the parenchyma of the liver, dried in the air for ſeveral years, and in the human muſcles altered by putrefaction, a ſubſtance which poſſeſſes characters very ſimilar to thoſe of ſpermaceti.

V. The eggs of birds, and particularly thoſe of poultry, are compoſed, 1. Of a bony ſhell, which contains a jelly, and calcareous phoſphat, as M. Berniard has proved. 2. Of a membranous pellicle, placed beneath the ſhell, and which appears to be an expanſion of fibrous matter. 3. Of a whitiſh fluid ſubſtance. 4. Of a yellow ſubſtance contained and ſuſpended in the middle of the white; the germ is ſupported on this laſt ſubſtance.

White of egg is abſolutely of the ſame nature as the ſerum of blood; it is viſcid and adheſive, it converts the ſyrup of violets to a green, and contains cretaceous ſoda in a diſengaged ſtate; expoſed to a gentle heat it coagulates into a white opake maſs, which emits an hepatic ſmell and gas. The white of egg coagulated and dried in a water-bath, affords an inſipid phlegm, which putrefies, and itſelf becomes dry and of a reddiſh tranſparency reſembling horn; by diſtillation in a retort, it affords ammoniacal chalk, and empyreumatic oil; its coal contains ſoda, and

and a ſmall quantity of calcareous phoſphat. M. Deyeux has likewiſe obtained a ſmall quantity of ſulphur by ſublimation.

White of egg expoſed to the air in fine ſtriæ, dries without putrefying, and forms a kind of tranſparent varniſh. It is diſſolved in water in all proportions; acids coagulate it, and if the coagulum diluted with water be filtered, the fluid which paſſes through affords by evaporation a neutral ſalt, conſiſting of the acid combined with ſoda: ſpirit of wine likewiſe coagulates the white of egg; lime-water precipitates calcareous phoſphat, and the mercurial nitre precipitates phoſphat of mercury, which by drying aſſumes a roſe colour.

The yolk of egg is for the moſt part compoſed of an albuminous ſubſtance, which is mixed with a certain quantity of a mild oil, ſo that the mixture diſſolves in water, and forms a kind of animal emulſion; if it be expoſed to heat, it becomes leſs ſolid than the white; when dried, it undergoes a kind of ſoftening, that ariſes from the diſengagement of its oil, which exudes from its ſurface in this ſtate; the oil may be obtained by preſſure, and is found to be mild and inſipid, and of a taſte and ſmell ſlightly empyreumatic. The yolk of egg, after the oil has been thus extracted, affords the ſame products by diſtillation as all other animal matters. Acids and ſpirit of wine coagulate it;

it; the mild oil it contains exhibits a ſtriking analogy between the eggs of animals and the ſeeds of vegetables, ſince theſe laſt likewiſe contain an oil which is in the ſame manner united with mucilage, and reduced to the emulſive ſtate.

Eggs are of great uſe as food; the different parts are uſed in pharmacy and in medicine; the calcined ſhell is uſed as an abſorbent; the oil of egg is ſoftening, and is externally uſed in burns, chaps, &c.; yolk of egg renders oil ſoluble in water, and forms lohochs; it is triturated with reſins, camphor, &c. The white of egg is ſucceſsfully uſed in pharmacy and confectionary, to clarify the juices of plants, wheys, ſyrups, and other fluids; it is likewiſe applied on paintings, which it preſerves by forming a tranſparent varniſh on their ſurface.

VI. Icthyocolla, or fiſh glue, is a ſubſtance partly gelatinous, and partly lymphatic, which is prepared by rolling up the membranes that form the air bladder of the ſturgeon, and ſeveral other fiſhes, and is dried in the air, after it has been twiſted into the form of a ſhort cord as we receive it. This ſubſtance affords a viſcid jelly by ebullition in water; by maceration for a certain time in that fluid, it may be unwrapped and extended into a kind of membrane. It is never brittle like the glaſs properly ſo called, but bends by virtue of its

 fibrous

fibrous elaſtic texture. A kind of glue is likewiſe prepared by boiling the ſkin of the ſtomach and inteſtines of fiſhes, but it has not the ſame properties as iſinglaſs or fiſh-glue. Icthyocolla affords all the products of other animal ſubſtances; it may be uſed in medicine as an emollient in diſorders of the throat, inteſtines, &c.; but many other vegetable ſubſtances which poſſeſs the ſame virtue, are commonly preferred. It is uſed in the arts to clarify liquors, wine, coffee, &c.; it attracts and precipitates all the foreign ſubſtances which affect their tranſparency.

CHAP. XXIII.

Concerning the Product of Oviparous Quadrupeds, Serpents, Inſects, and Worms, which are uſed in Medicine and the Arts.

THE turtle, the frog, the lizard, and the viper, are uſed in medicine, decoctions or ſoups being made with their fleſh and bones, to which peculiar virtues are attributed. It ſhould ſeem, in fact, that the zoophagous animals, whoſe humours are more attenuated than moſt quadrupeds; whoſe parts

parts in general have a ſtronger ſmell, and appear to contain more ſaline matter, ſince they afford a large quantity of volatile alkali, when diſtilled by a gentle heat, after trituration with oil of tartar; it ſhould ſeem, I ſay, that theſe animals muſt poſſeſs ſtronger and more numerous virtues. Many phyſicians, however, call their virtues in queſtion, and claſs them with other animals. Notwithſtanding this opinion, it is ſtill cuſtomary to adminiſter decoctions or ſoups of turtle and frogs in diſorders attended with languor, conſumptions without apparent cauſe, or any ſtate of weakneſs which ſucceeds acute fevers; and it is often found that good effects follow. Theſe decoctions appear to be more nouriſhing, lighter, and at the ſame time poſſeſſed of a certain activity, ſufficiently indicated by their ſtrong ſmell and peculiar taſte. Green lizards have been greatly recommended for ſome years paſt, in diſorders of the ſkin, cancers, &c.

Vipers are conſidered as the moſt active; the ancients ſpoke highly of their virtues in diſorders of the ſkin, in thoſe of the breaſt, and in chronical diſorders, wherein the lymph is vitiated. We cannot avoid thinking that their decoctions muſt throw off the vicious matter through the pores of the ſkin, by virtue of their exalted ſpiritus rector; their powder, and their volatile ſalt has nearly the ſame virtues; they

are ſtill adminiſtered in ſubſtance as food in the ſame diſorders, and with ſucceſs.

The chemical analyſis of theſe animals by M. Thouvenel, afforded a jelly, more or leſs light, conſiſtent, or viſcid, an acute bitter and deliqueſcent extract, an albuminous concreſcible ſubſtance, an ammoniacal ſalt, and an oily ſubſtance of a peculiar taſte and ſmell, ſometimes ſoluble in ſpirit of wine, &c.

II. Cantharides, a remedy of ſo great importance by its corroſive and epiſpaſtic quality, conſiſt, according to M. Thouvenel, 1. Of a parenchyma, whoſe nature he has not determined, and which amounts to half the weight of theſe dried inſects. 2. Of three drachms in the ounce, of a reddiſh, very bitter extractive ſubſtance, which affords an acid by diſtillation. 3. Of twelve grains per ounce of a yellow and wax-like matter, which produces the golden yellow colour of the cantharides; this ſubſtance when diſtilled, affords a very penetrating acid, and a concrete oil, reſembling wax; water diſſolves the extract, the yellow oil, and even a ſmall quantity of the green oil; but ether attacks only this laſt, and may be ſucceſsfully employed to ſeparate it from the others. The virtue of the cantharides depends on this kind of green wax. To obtain the latter, at the ſame time with the extractive ſubſtance, and to form in general

general a tincture well charged with these insects, a mixture of equal parts of spirit of wine and water must be used, this mixed tincture being distilled affords a spirit of wine with a slight odour of cantharides, and the different substances, it held in solution, are separated, one after the other, in proportion as the evaporation goes forward.

III. The acid of ants was observed by Tragus, Bauhine, and several other botanists. We observe the flower of chicory to become very red in an ant heap. Samuel Fisher, Etmuller, and Hoffman, have successively made experiments on this acid. Margraaf carefully examined it, and found that ants contain a peculiar acid, fat oil, and an extract. Messrs. Arvidson and Oerne, have made the most complete series of experiments on this acid. The acid of ants are obtained more especially from the red ant, formica rufa, by distilling them in a retort, and by washing them in boiling water. This acid, when rectified, and rather concentrated, has a penetrating smell, and is corrosive; its taste is agreeable when greatly diluted with water, and it has thence been proposed to be used instead of vinegar; it quickly reddens all blue vegetable colours, is decomposed by fire, which converts it into the cretaceous acid, and by the vitriolic and nitrous acids which disengage the same cretaceous acid: it deprives the dephlogisticated muriatic

muriatic acid of the baſe of air, and is ſtronger than the vitriolic, boraxic, cretaceous, acetous, and fuming nitrous acids. It forms a kind of ether with ſpirit of wine; the neutral ſalts it conſtitutes with alkaline baſes have been examined by Meſſrs. Arvidſon and Oerne. The formicate of pot-aſh has been prepared by M. Thouvenel, by ſpreading linen impregnated with pot-aſh on ant-hills uncovered; the ants running over the cloth emitted their acids, and odorant principle of the ſame nature, which they exhaled in ſo great an abundance, as to ſaturate the fixed alkali ſpread on the cloth. The lixivium of theſe linens afforded, by evaporation, a neutral ſalt cryſtallized in flat parallelograms, and priſmatic columns which were not deliqueſcent.

Lime with this acid forms a cryſtallizable and ſoluble ſalt; in a word, the modern chemiſts conſider the acid of ants as a peculiar acid, ſui generis.

Spirit of wine, digeſted on ants, extracts a ſmall quantity of eſſential oil, which with this fluid, forms the ſpirit of magnanimity of Hoffman. If theſe inſects be boiled in water, and afterwards preſſed, a fat oil is afforded, amounting to about thirteen drachms in the pound; this oil is of a greeniſh yellow, congeals at a much warmer temperature than oil of olives, and greatly reſembles wax. The water of the decoction affords a reddiſh brown extract by evaporation, which has a fe-
tid,

tid, acidulous, and caseous smell, with a bitter, nauseous, and acid taste. This extract is separated into two substances by the successive application of water and spirit of wine: the parenchyma of ants deprived of these different substances amounts to three ounces two drachms in the pound.

IV. The millipedes, acelli, porcelli, onisci, &c. presented certain peculiar circumstances in their analysis made by M. Thouvenel. By distillation on the water-bath without addition, they afford an insipid and alkaline phlegm, sometimes effervescing with acids, and converting the syrup of violets to a green: in this operation they lost five-eighths of their weight. By treatment with water and spirit of wine, they afterwards afforded two drachms of soluble matter, in the ounce; of which more than two-thirds were extractive matter, and the residue an oily or extractive substance. These two matters were easily separated by ether, which dissolves the latter without touching the extract; they differ from those of cantharides and ants, in affording more concrete volatile alkali, and no acid in their distillation. M. Thouvenel observes, on this subject, that among insects the millipedes appear to have the same relation to cantharides and ants, which reptiles have with respect to quadrupeds.

The neutral salts contained in these insects are very small in quantity, and very

 difficult

difficult to be extracted. M. Thouvenel affirms, that the millipedes and earth-worms, lumbrici, conftantly afforded him marine falt, with earthy bafes, and bafe of vegetable alkali; while in ants, and cantharides, thefe two bafes, the firft of which always appeared to him the moft abundant, are united with an acid, which has the character of the phofphoric acid. It is neceffary to be obferved here, that this chemift in his Differtation, has not defcribed either the methods of extracting thefe falts, nor the proceffes he made ufe of to afcertain their nature.

Cantharides and millipedes are only ufed in medicine; the latter appear to act as ftimulants, and flight diuretics, and for this purpofe they ought to be adminiftered according to the experiments of M. Thouvenel, in a much more confiderable dofe than is ufually prefcribed. The expreffed fluid of forty or fifty living millipedes given in a mild drink, or mixed with the juice of certain aperient plants, may be fuccefsfully prefcribed in the jaundice, ferous diforders, coagulations of the milk, &c. As to the cantharides, it is one of the moft powerful medicines we are in poffeffion of. M. Thouvenel tried on himfelf the effect of the green waxy matter, in which the virtue of thefe infects refides; when applied on the fkin in the quantity of nine grains, it raifed a blifter full of ferous matter, in the fame manner as the

the powder of cantharides; but the moſt valuable obſervations reſulting from his experiments on this powerful remedy, relate to the ſpirituous tincture of cantharides. He uſed it with the greateſt ſucceſs externally, in a doſe of two drachms to two ounces and an half, in rheumatic and ſciatic pains, and in the wandering gout; it heats the parts, accelerates the circulation, and excites evacuation by ſweat, urine, and ſtool, according to the parts on which it is applied. He likewiſe relates certain good effects ariſing from this tincture internally adminiſtered by foreign phyſicians, but young practitioners ought to be adviſed that the internal uſe of this medicine ſhould be very moderate, as it has been known to produce fluſhings on the ſkin, inflammations, ſweating of blood, and pains in the loins and bladder, dyſenteries, &c.

V. Honey and wax, prepared by bees, ſeem to belong to the vegetable kingdom, ſince theſe inſects collect the firſt in the nectaria of the flowers, and the ſecond in the antheræ of their ſtamina; nevertheleſs they have paſſed a peculiar elaboration, and beſides, as they are obtained in conſequence of the labour of bees, their properties ought to be examined in the hiſtory of inſects.

Honey is a ſubſtance perfectly reſembling ſaccharine juices, which we have treated of under vegetables. It has a white or yellowiſh

iſh colour, a ſoft and grained conſiſtence, a ſaccharine and aromatic ſmell; by means of ſpirit of wine, and even by water, with peculiar management, a true ſugar is obtained; by diſtillation it affords an acid phlegm and an oil, and its coal is light and ſpongy like that of the mucilages of plants. The nitrous acid extracts an acid intirely ſimilar to that of ſugar; it is very ſoluble in water, with which it forms a ſyrup, and like ſugar, paſſes to the ſpiritous fermentation; it is an excellent food, and a ſoftening, and ſlightly aperient medicine; it is given diſſolved in water, and mixed with vinegar, under the name of oximel. It is often combined with different acrid plants, as in the oxymel of ſquills, of colchicus; it is the vehicle in many medicines which bear its name, as the honey of roſes, water-lilly, mercurial honey, &c.

Wax is a concrete oily ſubſtance, ſimilar to ſolid fat oil, ſuch as the butter of cocoa, and ſtill more reſembling vegetable wax. Though it cannot be doubted that this ſubſtance is extracted from the ſtamina of flowers, it is nevertheleſs certain, that it receives a peculiar elaboration in the body of the animal; ſince, according to the trials of Reaumur, a flexible wax cannot be made with the powder of the antheræ. Wax which compoſes the honey-combs is yellow, and of an inſipid taſte; it is whitened by expoſure to the

the action of dew, and of the air. After it has been reduced into thin pieces, the aerated muriatic acid whitens it very quickly; by a gentle heat it softens, melts, and forms a transparent oily fluid, which becomes solid and opake by cooling; when strongly heated with the contact of air, it takes fire as soon as it is volatilized; and this is the effect produced by the wick in candles. When distilled in a retort it affords an acid phlegm, of a strong and penetrating smell; an oil at first fluid, which afterwards fixes in the receiver, and has the consistence of butter; and leaves only a very small quantity of coal difficult to incinerate. Butter of wax being rectified a number of times, becomes fluid and volatile; wax does not alter by exposure to the air, except that it becomes coloured at the end of a certain time. It dissolves in oil, to which it gives consistence; when melted in these fluids in a mild heat, it forms medicaments, known by the name of cerates; spirit of wine does not act on wax; acids blacken it, alkalis combine with it, and convert it into soap.

Wax is used in a great number of arts; in pharmacy it is used in the preparations of pomatums, unguents, and plasters.

VI. Silk worms contain, especially when in the state of chrysalis, an acid liquor in the reservoir placed near the anus. M. Chaussier, of the Academy of Dijon, obtained

tained this acid by expreſſing the juice of the chryſalides in a cloth, and precipitating the mucilage by ſpirit of wine, and likewiſe by infuſing the chryſalides in that liquor. This acid is very penetrating, of a yellow amber colour, but its nature and combinations are not yet known.

Many other inſects likewiſe contain acids; the large caterpillar of the willow emits a liquor conſiderably acid, according to the remark of M. Bonnet. I have often obſerved the bupreſtes and ſtaphylini give a red colour to the blue paper with which boxes were lined, wherein they were put. M. Chauſſier has likewiſe obtained an acid from the graſshopper, the red bug, the lampyris, or ſhining worm.

Silk, which ſeems to be nothing but a kind of gummy matter dried, differs nevertheleſs from vegetable ſubſtances, 1. By the volatile alkali it affords in diſtillation. 2. By the mephitis obtained from it, by means of the nitrous acid. 3. By the peculiar oil which this acid ſeparates in proportion as it converts it into ſaccharine acid, as M. Berthollet has ſhewn. It ſeems to be a compound of vegetable mucilage with a peculiar animal oil, which gives it flexibility, ductility, and elaſticity.

VII. The improper name of gum lac is given to a reſinous ſubſtance of a deep red, which is depoſited on the branches of trees, by

by a kind of ant peculiar to the Eaſt-Indies. This ſubſtance appeared to Geoffroy to be a kind of nidus, in which the ants depoſit their eggs. In fact, if ſtick-lac be broken, it is obſerved to be full of ſmall cavities, or regular cellules, in which ſmall oblong bodies are placed, which Geoffroy has conſidered as the embryoes of ants. He thinks that the lac owes its colour to this animal ſubſtance; he regards the lac as a true wax, though its dryneſs, the aromatic odour it exhales in burning, and its ſolubility in ſpirit of wine, ſeem to indicate a reſemblance between it and reſins; by diſtillation it affords a kind of butter, according to the ſame author. It is diſtinguiſhed in commerce into ſtick-lac, ſeed-lac, and ſhell-lac. It is uſed in the Levant to dye cloths and ſkins. It is the baſis of ſealing wax; a tincture is made with it, together with the ſpirit of cochlearia; it enters into the troches of amber, dentrifrice powders, and opiates, odorous paſtills, &c.

VIII. Kermes, Cocus infectorius, was conſidered by the firſt naturaliſts as a tubercle and excreſcent of plants. The more accurate obſervations of ſubſequent times have ſhewn, that it is the female of an inſect arranged among hemiptera by Geoffroy; this female fixes itſelf among the leaves of the holm, where, after having been fecundated, it extends itſelf, dies, and ſoon loſes the form

of

of an inſect; it has the appearance of a brown red cap, under which are incloſed a very great number of eggs. This cap was formerly uſed in dying, but has been neglected ſince the diſcovery of cochineal. Kermes exhibits the ſame chemical properties as this laſt ſubſtance; it enters into the confectio alkermes.

IX. Cochineal, like kermes, was long conſidered as a vegetable grain. Father Plumier is among the firſt who detected this error; it is, in fact, the female of an inſect which differs from the kermes in the circumſtance that it preſerves its form, though fixed on the plants. The cochineal uſed in dying grows on the opuntia or Indian fig; it is collected in great quantities in South America. Geoffroy, who analyzed it, found it to contain the ſame principles as kermes; he obtained the volatile alkali from it. The form of this inſect may be ſeen by macerating it in water. Cochineal is uſed to make carmine, and in dying it produces either a crimſon or ſcarlet colour, according to the manner in which it is uſed. As it is an extractive colouring matter, it cannot be applied in ſubſtances intended to be dyed, but by the help of a corroſive. It readily adheres to wool, and tinges it of a ſcarlet colour, by means of the ſolution of tin in aqua regia, which decompoſes the colouring extract, and ſingularly enlivens the tinge.

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The method of giving this beautiful colour to ſilk was not known before the time of Macquer; this celebrated chemiſt diſcovered that ſilk may be dyed, if previouſly impregnated with the ſolution of tin, before it is plunged in the bath of cochineal, inſtead of mixing the ſolution in the bath, as is done with wool.

X. The ſtrong concretions falſely called crabs eyes, lapides cancrorum, are found in the number of two in the internal and interior parts of the ſtomach of theſe inſects; they are round, convex on one ſide, concave on the other, and placed in the animal between the two membranes of the ventricle. As they are not found, but at the time in which the crabs change their covering and their ſtomach; and as they diſappear gradually in proportion as the new covering becomes hard, it is thought, with great probability, that they ſerve to re-produce the calcareous ſubſtance, which conſtitutes the baſis of their ſhells.

Theſe ſtones have no taſte; they contain a ſmall quantity of gelatinous matter; they are prepared by repeated waſhing and grinding on a ſtone with a ſmall quantity of water to reduce them into a ſoft paſte, which is moulded into lozenges and dried; the water carrying off the animal jelly contained in theſe ſtones; the reſidue is mere earthy matter. When prepared in this manner, they make

make a ſtrong effervescence with all acids, and are abſolutely of the ſame nature as chalk; they have, therefore, no other virtue than that of abſorbing acidities in the firſt paſſages; and the opinions in conſequence of which animal ſubſtances in general have been placed in the rank of aperient, diuretic, and even cordial remedies, are very far from being well founded.

XI. The ſame obſervation likewiſe applies to coral, which is a calcareous white earth, or roſe-coloured ramification, forming the baſis of the habitation of the ſea polypi. Preparations of theſe are made in the ſame manner as from crabs eyes, and it is of the ſame calcareous nature as that ſubſtance; it enters into the confectio alkermes, pulvis gutteti, amber troches, &c. Numberleſs virtues have been attributed to it, but it poſſeſſes no other than that of a mere abſorbent, unleſs it be combined with acids; this, as well as crabs eyes, is often in the ſtate of a neutral ſalt, combined with vinegar or lemon juice, as an aſperient diuretic, &c.

XII. The coralline, called ſea-moſs, is, as we have obſerved, a peculiar habitation of polypi. It affords the ſame principles in the retort as animal ſubſtances, and has a ſalt, bitter, and diſagreeable taſte; it is ſucceſsfully uſed as a vermifuge, with which intention it is preſcribed in powder, in

in the doſe of twenty-four grains for infants, to that of two drachms or more for adults. It is made into an anthelminthic ſyrup, and enters into vermifuge powders. This common coralline muſt not be confounded with the ſubſtance at preſent called coralline of Corſica, or helminto-corton: this laſt is a vegetable, a kind of fucus, which has the property of forming a jelly with hot water.

CHAP. XXIV.

Concerning the Putrefaction of Animal Subſtances.

THOUGH vegetable ſubſtances are ſuſceptible of decompoſition, and intire deſtruction, by the putrid fermentation, they are nevertheleſs in general far from being as capable of entering into this ſtate of inteſtine motion as animal matters; the putrefaction of theſe laſt is much more rapid and its phenomena are different: all the fluids and ſoft parts of animals are alike capable of undergoing this proceſs, while many vegetable matters ſeem exempted from it, or at leaſt are not changed by it but ſlowly, and with great difficulty.

The putrefaction of animals, which we cannot but conſider, with Boerhaave, as a

true fermentation, is one of the moſt important, and at the ſame time the moſt difficult to be known; all the labours of the philoſophical world, ſince the time of Lord Chancellor Bacon, who was well aware of the importance of inquiries into this ſubject, have ſerved only to clear up a few circumſtances, and to exhibit the general phenomena of putrefying ſubſtances. Beccher, Hales, Stahl, Pringle, Macbride, Geber, Baumé, the valuable author of the Eſſays on Putrefaction, and thoſe of the Diſſertations on Antiſeptics, which were crowned in 1767 by the Academy of Dijon, have obſerved, and carefully deſcribed the facts which accompany the putrid change in bodies: but we ſhall ſee, in the following pages, that a great number of experiments remains to be made, before we can eſteem ourſelves acquainted with the whole of the phenomena of this natural operation.

Every fluid or ſoft animal ſubſtance, expoſed to a moderate temperature, of ſixty-five degrees or more, paſſes with more or leſs rapidity through the following changes. Its colour becomes paler, and its conſiſtence diminiſhes; if it be a ſolid part, ſuch as fleſh, it ſoftens, and a ſerous matter ſweats out, whoſe colour quickly changes; its texture becomes relaxed, and its organization deſtroyed; its ſmell becomes faint, and diſagreeable; the ſubſtance gradually ſinks down,

down, and is diminiſhed in bulk; its ſmell becomes ſtronger, and alkaline. If the ſubject be contained in a cloſe veſſel, the progreſs of putrefaction, at this ſtage, ſeems to ſlacken; no other ſmell but that of a pungent alkali is perceived; the matter effer- veſces with acids, and converts ſyrup of violets to a green. But if the communication with the air be admitted, the urinous exhalation is diſſipated, and a peculiar putrid ſmell is ſpread around, with a kind of impetuoſity;—a ſmell of the moſt inſupportable kind, which laſts a long time, and pervades every place, affecting the bodies of living animals, after the manner of a ferment, capable of altering the fluids: this ſmell is corrected, and as it were confined by the volatile alkali. When the latter is volatilized, the putrefactive proceſs becomes active a ſecond time, and the ſubſtance ſuddenly ſwells up, becomes filled with bubbles of air, and ſoon after ſubſides again. Its colour changes, the fibrous texture of the fleſh being then ſcarcely diſtinguiſhable; and the whole is changed into a ſoft, brown, or greeniſh matter, of the conſiſtence of a poultice, whoſe ſmell is faint, nauſeous, and very active on the bodies of animals. The odorant principle gradually loſes its force; the fluid portion of the fleſh aſſumes a kind of conſiſtence, its colour becomes deeper, and it is finally re-

duced into a friable matter, rather deliquescent, which being rubbed between the fingers, breaks into a coarse powder, like earth. This is the last state observed in the putrefaction of animal substances; they do not arrive at this term but at the end of a considerable time. Eighteen months, two, and even three years, are scarcely sufficient for the destruction of the whole body of animals exposed to the air; and the time necessary for the total destruction of bodies buried in the earth has not yet been estimated. Not to mention bodies which in certain soils are dried, and remain unchangeable; many facts prove, that human bodies, buried in great numbers in a moist soil, are not destroyed even at the end of thirty years.

From this outline it follows, 1. That the conditions proper to develope and maintain the putrefaction of animal substances, are the contact of air, heat, moisture, and repose. 2. That the volatile alkali is the product of putrefaction, formed during that process, since it did not exist as such in the animal substances before the commencement of that intestine motion. 3. That putrefaction, effected by the intestine motion, proper to organized matters, may be compared to the action of fire, as Mr. Goddard has remarked, and may be considered as spontaneous decomposition, as M. Baumé thinks, from which

which it differs only in its ſlowneſs. 4. That in this natural operation, the proximate principles of animals re-act on each other, by the aſſiſtance of water and of heat, by means of which the motion commenced; that the volatile matters thus formed, become gradually diſſipated in the order of their volatility, and that nothing remains after the putrefaction, but an inſipid, and as it were earthy ſubſtance. 5, and laſtly, That the putrid exhalation, which is ſo well diſtinguiſhed by the nerves of ſmell, and whoſe action is ſo powerful on the animal economy, may be conſidered as one of the principal products of putrefaction, as it is peculiar to this operation, and is not obſerved in any other natural phenomena; and becauſe it appears capable of developing the putrefactive motion in all the animal ſubſtances which are expoſed to its action. As to the nature of this fugacious odorant ſubſtance, we muſt obſerve, that it is more particularly with reſpect to this that inquiries are very little advanced, though they highly deſerve to be followed. We only know, that it is extremely volatile, attenuated, and penetrating; that pure air, water in large quantities, and acid gaſes, are capable of moderating its effects. Though it ought not to be confounded with the cretaceous acid, or fixed air, which is diſengaged in large quantities

 from

from putrefying bodies, and to whofe difengagement Macbride intirely attributed the caufe of this natural phenomenon; and though we are by no means warranted in comparing it, either to the inflammable gas difengaged from putrefcent bodies, nor with the luminous matter, which fhines at the furface of putrid animal fibres, converting them into a kind of phofphorus; yet it muft be allowed, that thefe fubftances have very evident relations with each other, fince it always accompanies them, is equally volatile and attenuating, and acts with equal energy on the organs of animals. Four degrees or ftages of the putrid of fermentation may be diftinguifhed, according to M. Boiffieu.

The firft, which this phyfician calls a tendency to putrefaction, confifts in an alteration, not confiderable, which appears by a faint or flight fmell, and a foftening of the fubftance.

The fecond degree, or commencement of putrefaction, is fometimes indicated by marks of acidity: the fubftances which undergo this, lofe weight, become fetid and foft, and a ferous matter exudes, if they be in clofe veffels; or they become dry, and of a dark colour, if expofed to the air.

In the third degree, or advanced ftage of putrefaction, the putrefcent matters emit an alkaline fmell, mixed with the putrid and naufeous

nauſeous ſmell; they fall into diſſolution, their colour changes more and more, and they loſe at the ſame time both weight and bulk.

Laſtly, the fourth degree, or that of complete putrefaction, is known by the volatile alkali being intirely and completely diſſipated; the fetid ſmell loſes its force, the volume and weight of the putrefied ſubſtance are conſiderably diminiſhed, a gelatinous mucus is ſeparated, they dry by degrees, and are at length reduced to a friable and earthy matter.

Such are the general phenomena obſerved in the putrefaction of animal ſubſtances, but they are far from being the ſame in all matters which putrefy. There is a great difference between the putrefaction of the parts of living animals, and that of their dead organs. The motion which exiſts in the former, ſingularly modifies the phenomena of this alteration; and phyſicians have frequent opportunities of obſerving the difference between theſe two ſtates, with reſpect to putrefaction. Beſides this, every humour, and every ſolid part, ſeparated from a dead animal, has likewiſe its peculiar manner of putrefying. The muſcular, membranous, or parenchymatous texture of the organs; the oily, mucilaginous, or lymphatic nature of the humours, their conſiſtence, their ſtate with reſpect to

that of the animal which afforded them, greatly influence the putrefactive motion, and modify it in a thousand manners, perhaps impossible to be estimated. And how greatly will the difficulty of the subject be increased, if we add to this enumeration, the state of the air, its temperature, elasticity, weight, dryness, or moisture; the exposition of the putrefying substance in various places, and even the form of the vessels which contain it; all these circumstances being capable of varying the phenomena? It must therefore be allowed, that the history of animal putrefaction is scarcely begun, and that it demands an immense series of inquiries and experiments.

The phenomena hitherto observed shew, that water is the cause of putrefaction; it is most probable that this fluid is decomposed, that its oxyginous principle seizes the mephitis of the animal substances, and contributes to the formation of the nitrous acid, so frequently found in animal matters; and that the inflammable gas of the water, united to a portion of the same mephitis, which abounds in these substances, produces the volatile alkali that flies off. The oily principle is preserved for the longest time; the calcareous phosphat, and the phosphat of soda, united to a portion of the carbonaceous principle, and perhaps with a small quantity

tity of the fat matter, ſeem to conſtitute the apparently earthy reſidue of putrefied animal matters.

Theſe general data are ſufficient to ſhew, that putrefaction ſeparates and volatilizes the principles of animal matters; that nature reduces them, by the ſlow decompoſition of dead animals, to the moſt ſimple ſubſtances, deſtined to enter into new combinations; and that it is in this manner that the purpoſes of the general ſyſtem are accompliſhed, by the continual change of the form and nature of bodies, which paſs without intermiſſion from one kingdom to another.

THE END.

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Table I.

The Division and Characters of the Eight Classes of Animals, by Daubenton.

A N I M A L S.

Having an Head.							The most Part having no Head.
With Nostrils.						Without Nostrils.	
With Ears.						Without Ears.	
Two Ventricles in the Heart.			One Ventricle in the Heart.			The Heart variously formed, or unknown.	
Warm Blood.			Blood nearly cold.			A whitish Fluid, instead of Blood.	
Inspiring and expiring the Air frequently.			Inspiring and expiring the Air, at long Intervals.		Admitting the Air by Gills.	Admitting the Air by Spiracula.	No apparent Entrance or Aperture to admit Air.
Vivaparous.		Oviparous.					
With Teats.		Without Teats.					
1st Order. QUADRUPEDS.	2d Order. CRETACEOUS ANIMALS.	3d Order. BIRDS.	4th Order. OVIPAROUS QUADRUPEDS.	5th Order. SERPENTS.	6th Order. FISHES.	7th Order. INSECTS.	8th Order. WORMS.
Four Feet and hairy Skin.	Fins and no Hair.	Feathered.	Four Feet and no Hair.	Scaly, without Feet or Fins.	Scaly, with Fins.	Having Antennæ.	Having neither Feet nor Scales.

Table II.

Quadrupeds, divided according to the Syſtem of BRISSON.

			ORDERS.	SECTIONS.				GENERA.	
QUADRUPEDS,	Without teeth		I.	Hairy ſkin				Ant-eater	*Myrmecophaga.*
			I.	Scaly				Manis	*Pholidotus.*
	With teeth.	With grinders only	II.	Hairy ſkin				Sloth	*Tardigradus.*
			II.	Bony covering or ſhell				Armadillo	*Cataphractus.*
		Grinders and canine teeth only	III.	Two long tuſks and a trunk				Elephant	*Elephas.*
			III.	Two long tuſks, no trunk				Sea Cow	*Odobenus.*
		Inciſive teeth in the lower jaw only.	IV.	Ruminant, ungulated; ſix inciſive teeth				Camel	*Camelus.*
			V.	Ruminant, with cloven feet; eight inciſive teeth.	Simple horns.	Turned upwards.	Fore legs longer than hinder legs	Camelopardalis	*Giraffa.*
			V.		Simple horns.	Turned upwards.	The legs of equal lengths	Goat	*Hircus.*
			V.		Simple horns.	Turned back		Sheep	*Aries.*
			V.		Simple horns.	Turned ſideways		Ox	*Bos.*
			V.		Branched horns			Stag	*Cervus.*
			V.		No horns			Muſk	*Tragulus.*
		Inciſive teeth in both jaws. Ungulated feet	VI.	The hoof entire.				Horſe	*Equus.*
			VII.	The Hoof cloven				Hog	*Sus.*
			VIII.	Three ungulated toes on each foot,				Rhinoceros	*Rhinoceros.*
			IX.	Four ungulated toes before, three behind,	Two inciſive teeth in each jaw			River Hog	*Hydrochærus.*
			X.	Four ungulated toes before, three behind,	Ten inciſive teeth in each jaw,			Tapir	*Tapirus.*
			XI.	Four ungulated toes on each foot				River Horſe	*Hippopotamus.*
		Ungulated feet, and two inciſive teeth in each jaw.	XII.	Without canine teeth	Spines on the body			Porcupine	*Hyſtrix.*
			XII.	Without canine teeth	Without ſpines.	Tail flat and ſcaly		Beaver	*Caſtor.*
			XII.	Without canine teeth	Without ſpines.	Short tail	Long ears	Hare	*Lepus*
			XII.	Without canine teeth	Without ſpines.	Short tail	Short ears	Coney	*Cuniculus.*
			XII.	Without canine teeth	Without ſpines.	Long tail,	Flat	Squirrel	*Sciurus.*
			XII.	Without canine teeth	Without ſpines.	Long tail,	Round	Dormouſe	*Glis.*
			XII.	Without canine teeth	Without ſpines.	Naked tail		Rat	*Mus.*
			XII.	With canine teeth	Without ſpines on the body			Shrew Mouſe	*Muſaraneus.*
			XII.	With canine teeth	With ſpines			Hedge Hog	*Erinaceus.*
		Four inciſive teeth in each jaw	XIII.	Separate toes				Monkey	*Simia.*
			XIII.	Toes joined by a membrane ſo as to form wings					*Pteropus.*
		Four inciſive teeth in the upper, and ſix in the lower jaw.	XIV.	Separate toes				Maucauco	*Proſimia.*
			XIV.	The fore toe joined ſo as to form wings				Bat	*Veſpertilio.*
		Six inciſive teeth in the upper, and four in the lower jaw.	XV.					Seal	*Phoca.*
		Six inciſive teeth in each jaw.	XVI.	The toes ſeparate from each other.	Four toes on the fore, and five on the hinder feet			Hyæna	*Hyæna.*
			XVI.	The toes ſeparate from each other.	Five toes on the fore, and four on the hinder feet			Dog	*Canis.*
			XVI.	The toes ſeparate from each other.	Five toes on each foot,	Firſt toe remote from the other,		Weezel	*Muſtela.*
			XVI.	The toes ſeparate from each other.	Five toes on each foot,	Firſt toe near the other		Badger	*Meles.*
			XVI.	The toes ſeparate from each other.	Feet which reſt on the heel in walking			Bear	*Urſus.*
			XVI.	The toes ſeparate from each other.	Hooked claws which may be drawn back and concealed			Cat	*Felis.*
			XVI.	The toes joined together by a membrane				Otter	*Lutra.*
		Six inciſive teeth in the upper, and eight in the lower jaw.	XVII.					Mole	*Talpa.*
		Ten inciſive teeth in the upper, and eight in the lower jaw.	XVIII.					Opoſſum	*Philander.*

Table III.

The Ornithologic System of BRISSON.

BIRDS ARE

- Either CLOVEN FOOTED, that is, they have the toes naked, and apart from each other.
  - The legs feathered as low as the calcaneum, or bone which sustains the toes.
    - Four toes all separate from each other, quite to their base.
      - Three toes before and one behind. — Orders I.–XII.
      - Two toes before and two behind — XIII.
    - The middle toe united with the exterior, for the space of three phalanges, and with the interior for the space of one phalanx; four toes; three before, one behind. — XIV.
  - The lower part of the legs without feathers.
    - Wings too small for flight — XV.
    - Wings large enough for flight.
      - Three toes only, all before. — XVI.
      - Three toes before, and one behind. — XVII.
- or WEB-FOOTED; that is, they have the toes furnished with membranes.
  - The membranes of the feet divided. Four toes; three before and one behind, which are divided, and have membranous edges. — XVIII.
  - The membranes partly divided; the toes joined together near their base; the legs placed behind near the anus. — XIX.
  - The membranes entire.
    - The legs placed behind near the anus.
      - Three toes before, connected by a membrane; no toe behind. — XX.
      - Three toes before, connected by a membrane; one separate toe behind. — XXI.
    - The legs placed in the middle of the body, and shorter than it.
      - The three anterior toes connected by a membrane.
        - Without a posterior toe. — XXII.
        - A fourth toe behind, separate from the others.
          - Indented beak — XXIII.
          - Beak not indented — XXIV.
      - The four toes connected by a membrane — XXV.
    - The legs longer than the body. — XXVI.

ORDERS.		SECTIONS.	GENERA.	
I.	The beak strait; the upper mandible thickened, and somewhat curved at the point; the nostrils half covered with a thick soft membrane. It consists of one genus only.	—	Pigeon	*Columba.*
II.	The beak conical and curved. It consists of six genera.	Sections. 1. The head ornamented with appendices.	Turkey	*Gallo Pavo.*
			Cock and Hen	*Gallus.*
			Guinea Hen	*Meleagris.*
		2. No appendices on the head.	Grous	*Lagopus.*
			Partridge	*Perdix.*
			Pheasant	*Phasianus.*
III	The beak short and crooked. It consists of five genera.	1. The base of the beak covered with a naked skin.	Hawk	*Accipiter.*
			Eagle	*Aquila.*
			Vulture	*Vultur.*
		2. The base of the beak covered with feathers turned forwards.	Owl	*Asio.* *Strix.*
IV.	The beak long and conical. It consists of six genera.	1. The feathers on the base of the beak turned forward, and covering the nostrils.	Chough	*Coracia.*
			Crow	*Corvus.*
			Magpie	*Pica.*
		2. The feathers at the base of the beak turned backward; the nostrils uncovered.	Roller	*Galgulus.*
			Oriole	*Icterus.*
			Bird of Paradise	*Manucodiata.*
V.	The beak strait; the upper mandible grooved on each side towards the point. It consists of four genera.	1. The beak convex above.	Butcher Bird	*Lanius.*
			Thrush	*Turdus.*
			Chatterer	*Cotinga.*
		2. The beak flattened horizontally towards the base, and nearly triangular.	Fly catcher	*Muscicapa.*
VI.	The beak strait, and the mandibles not grooved. It consists of two genera.	—	Beef-eater	*Buphagus.*
			Starling	*Sturnus.*
VII.	The beak slender and rather bent. It consists of two genera.	—	Hoopoe	*Upupa.*
			Promerops	*Promerops.*
VIII.	The beak very small, flattened horizontally at its base, and bent at the point; the opening of the mouth appears larger than the head. It consists of two genera.	—	Goat-sucker	*Caprimulgus.*
			Swallow	*Hirundo.*
IX.	The beak conical, and gradually diminishing to the point. It consists of eight genera.	1. The two mandibles strait.	Tanager	*Tangara.*
			Goldfinch	*Carduelis.*
			Sparrow	*Passer.*
			Grosbeak	*Coccothraustes.*
			Bunting	*Emberiza.*
			Coly	*Colius.*
			Bulfinch	*Pyrrhula.*
		2. The two mandibles crossing each other.	Crossbill	*Loxia.*
X.	The beak awl-shaped. It consists of three genera.	1. The nostrils uncovered.	Lark	*Alauda.*
			Beccafico	*Ficedula.*
		2. The nostrils covered by the feathers at the base of the beak.	Tit-mouse	*Parus.*
XI.	The beak wedge-shaped. It consists of one genus only.	—	Nuthatch	*Sitta.*
XII.	The beak filiform. It consists of three genera.	1. The beak curved.	Creeper	*Certhia.*
		2. The beak flattened horizontally, and a little enlarged at the point; the feet very short.	Humming Bird	*Polytmus.* *Mellisuga.*
XIII.	Consisting of nine genera.	1. The tongue very long and vermiform, but not longer than the beak.	Wryneck	*Torquilla.*
			Wood-pecker	*Picus.*
		2. The beak very long, quadrangular, and pointed.	Jacamar	*Galbula.*
		3. The beak somewhat curved, convex at its upper part, and flattened laterally.	Barbet	*Bucco.*
			Cuckow	*Cuculus*
		4. The beak short and crooked	Curucui	*Trogon.*
			Ani	*Crotophagus.*
			Parrot	*Psittacus.*
		5. The beak long, and as thick as the head, indented like a saw; the point of each mandible turned downwards.	Toucan	*Tucana.*
XIV.	seven genera.	1. The beak short and flattened laterally near the point.	—	*Rupicola.*
			Manakin	*Manacus.*
		2. The beak conical and indented like a saw; the end of each mandible bent downwards.	Motmot	*Momotus.*
		3. The beak strait and of a moderate length.	King's-fisher	*Ispida.*
			Tody	*Todus.*
		4. The beak curved and sharp.	Bee-eater	*Apiaster.*
		5. The beak thick and formed like a scythe.	Hornbill	*Hydrocorax.*
XV.	four genera	1. Two toes before, none behind; the beak strait, somewhat flattened horizontally, and curved at the point; the upper part of the head bald & scaly.	Ostrich	*Struthio.*
		2. Three toes before, none behind,	—	*Rhea.*
			Casuary	*Casuarius.*
		3. Three toes before, one behind; the beak long and strong; both mandibles hooked at the point.	Dodo	*Raphus.*
XVI.	four genera	1. The beak conical and curved.	Bustard	*Otis.*
		2. The beak strait and thickest at the point.	Long-Legs	*Himantopus.*
			Oyster-catcher	*Ostralega.*
			Plover	*Pluvialis.*
XVII.	eighteen genera.	1. The beak strait and thickest near the point.	Lapwing	*Vanellus.*
			Jacana	*Jacana.*
		2. The beak a little turned up, and somewhat flattened horizontally.	Turnstone	*Arenaria.*
		3. The beak convex above, and flattened laterally	Pratincole	*Glareola.*
		4. The beak strait and flattened laterally.	Rail	*Rallus.*
		5. The beak strait and slender.	Sandpiper	*Tringa.*
			Godwit	*Limosa.*
			Woodcock	*Scolopax.*
		6. The beak curved in an arc downwards.	Curlew	*Numenius.*
		7. The beak strait, flattened horizontally, and dilated at its extremity like a spatula.	Spoonbill	*Platea.*
		8. The beak long and thick.	Stork	*Ciconia.*
			Heron	*Ardea.*
			Umbre	*Scopus.*
		9. The beak short and thick, the upper mandible in the form of a spoon.	Boat-bill	*Cochlearius.*
		10. The beak short and strait, conical at the point; the head adorned with a crown of feathers.	Crown Bird	*Balearica.*
		11. The beak conical and curved.	Cariama	*Cariama.*
			Screamer	*Anhima.*
		12. The beak conical, flattened at the sides, and the fore part of the head without feathers.	Gallinule	*Porphyrio.*
XVIII.	three genera	1. The membranes of the toes simple, the beak strait and acute.	Water Hen	*Gallinula.*
			Phalarope	*Phalaropus.*
		2. The membranes of the toes jagged.	Coot	*Fulica.*
XIX.	one genus	—	Grebe	*Colymbus.*
XX.	three genera	1. The beak strait and acute.	Guillemot	*Uria.*
		2. The beak flattened at the sides, with transverse striæ.	Puffin	*Fratercula.*
			Auk	*Alca.*
XXI.	three genera	1. The beak strait, the extremity of the upper mandible bent.	Pinguin	*Spheniscus.*
			—	*Catarractes.*
		2. The beak strait and acute.	Diver	*Mergus.*
XXII.	one genus	—	Albatross	*Albatrus.*
XXIII.	six genera	1. The beak bent near its point.	Shearwater	*Puffinus.*
			Petrel	*Procellaria.*
			Arctic Bird	*Stercorarius.*
			Gull	*Larus.*
		2. The beak flattened at the sides.	Tern	*Sterna.*
			Razorbill	*Rygchopsalia.*
XXIV.	three genera	1. The beak rather cylindrical; the extremity of the upper mandible bent.	Merganser	*Merganser.*
		2. The beak convex on its upper part, and flat beneath.	Goose	*Anser.*
			Duck	*Anas.*
XXV.	five genera	1 The beak acute.	Darter	*Anhinga.*
			Tropic Bird	*Lepturus.*
		2. The beak hooked at the point.	Booby	*Sula.*
			Cormorant	*Phalacrocorax.*
			Pelican	*Onocrotalus.*
XXVI.	three genera	1. The beak indented, curved in the middle, and the inferior mandible largest.	Flamingo	*Phœnicopterus.*
		2. The beak not indented.	Avoset	*Avocetta.*
			Courier	*Corrira.*

Table IV. *The Diviſion of oviparous Quadrupeds, by* DAUBENTON.

OVIPAROUS QUADRUPEDS.	CLASS I. The body covered with a ſhell. TORTOISES.		Conſiſting of 15 ſpecies.
	CLASS II. The body naked, with a tail. Lizards.	Genus I. Lizards which have the body ſomewhat tuberculated, and the tail flat.	Conſiſting of 8 ſpecies.
		Genus II. Lizards which have the tail verticillated.	Conſiſting of 12 ſpecies.
		Genus III. Lizards which have the tail round, ſcaly, and ſhorter than the body.	Conſiſting of 5 ſpecies.
		Genus IV. Lizards which have the tail round, ſcaly, and longer than the body	Conſiſting of 17 ſpecies.
		Genus V. Lizards which have four toes on the fore feet, and the body ſmooth.	Conſiſting of 5 ſpecies.
		Genus VI. Winged Lizards.	The Dragon.
	CLASS III. The body naked, without a tail.	Genus I. Toads; the body round and tuberculated, the legs ſhort.	Conſiſting of 14 ſpecies.
		Genus II. Frogs which have the body long.	Conſiſting of 11 ſpecies.
		Genus III. Frogs which have the toes terminating in a broad flat ſurface.	Conſiſting of 9 ſpecies.

Table V. *The Division of Serpents by* DAUBENTON.

SERPENTS.	Genus I.	Rattle-snakes; or such as have a Rattle at the extremity of the tail. Crotalus, Linnæi.	It consists of four species.
	Genus II.	Serpents which have large scales (Scuta) beneath the body and tail; without a Rattle. Boa, Linn.	It consists of ten species.
	Genus III.	Serpents which have large scales (Scuta) beneath the body, and small scales (Squamæ) beneath the tail. Coluber, Linn.	It consists of ninety-six species.
	Genus IV.	Serpents which have small scales beneath the body and tail. Anguis, Linn.	It consists of thirteen species.
	Genus V.	Serpents which have the body divided into annuli or rings. Amphisbæna, Linn.	It consists of two species.
	Genus VI.	Serpents which have the skin naked smooth. Cæcilia, Linn.	It consists of two species.

FISHES have either

- **The gills perfect,**
  - **Claſs I. ACANTHOPTERYGII.** The fins ſupported by ſmall bones.
    - **Order I. Apodes.** The ventral fins wanting.

1.	———	*Trichiurus.*
2.	Sword-fiſh	*Xiphias.*
3.	———	*Ophidium.*

    - **Order II. Jugulares,** The belly-fins placed beneath the neck.

1.	Weveer	*Trachinus.*
2.	———	*Uranoſcopus.*
3.	Dragonet	*Callyonymus.*
4.	Blenny	*Blennius.*

    - **Order III. Thoracici.** The ventral fins placed beneath the breaſt.

1.	Goby	*Gobius.*
2.	———	*Cepola.*
3.	Dolphin	*Coryphæna.*
4.	Mackrel	*Scomber.*
5.	Wraſſe	*Labrus.*
6.	Gilthead	*Sparus.*
7.	———	*Chætodon.*
8.	———	*Sciæna.*
9.	Perch	*Perca.*
10.	Father Laſher	*Scorpæna.*
11.	Surmullet	*Mullus.*
12.	Gurnard	*Trigla.*
13.	Bull-head	*Cottus.*
14.	Doree	*Zeus.*
15.	———	*Trachipterus.*
16.	Stickle-back	*Gaſteroſteus.*

    - **Order IV. Abdominales.** The ventral fins placed beneath the abdomen.

1.	Catfiſh	*Silurus.*
2.	Mullet	*Mugil.*
3.	———	*Polynemus.*
4.	———	*Theutys.*
5.	———	*Elops.*

  - **Claſs II. MALACOPTERYGII.** The fins ſoft, and without bones.
    - **Order I. Apodes.**

1.	Eel	*Muræna.*
2.	Gymnotus	*Gymnotus.*
3.	Wolf-fiſh	*Anarhichas.*
4.	———	*Stromateus.*
5.	Launce	*Ammodytes.*

    - **Order II. Jugulares.**

1.	———	*Lepadogaſter.*
2.	Cod	*Gadus.*

    - **Order III. Thoracici.**

1.	Flounder	*Pleuronectes.*
2.	Sucking-fiſh	*Echeneis.*
3.	———	*Lepidopus.*

    - **Order IV. Abdominales.**

1.	———	*Loricaria.*
2.	Atherine	*Atherina.*
3.	Salmon	*Salmo.*
4.	———	*Fiſtularia.*
5.	Pike	*Eſox.*
6.	Argentine	*Argentina.*
7.	Herring	*Clupea.*
8.	Flying fiſh	*Exocœtus.*
9.	Carp	*Cyprinus.*
10.	Loche	*Cobitis.*
11.	———	*Amia.*
12.	———	*Mormyrus.*

- **OR The gills imperfect.**
  - **Claſs III. BRANCHIOSTEGI.**
    - **Order I. Apodes.**

1.	Pipe-fiſh	*Syngnathus.*
2.	Baliſtes	*Baliſtes.*
3.	———	*Oſtracion.*
4.	———	*Tetraodon.*
5.	Sun-fiſh	*Diodon.*

    - **Order II. Jugulares.**

1	Angler	*Lophius.*

    - **Order III. Thoracici.**

1.	Lump-fiſh	*Cyclopterus.*

    - **Order IV Abdominales.**

1.	———	*Centriſcus.*
2.	———	*Pegaſus.*

Table VII. *The Entomologic Method of*, GEOFFROY.

SECTIONS.	ARTICLES.	ORDERS.	GENERA.
Sect. I. Coleoptera, or Insects with crustaceous shells over their wings	I. . . . Either the shell is hard, and covers the whole abdomen, and their feet have	I. . . . Either five articulations to all the feet, such as the	*Platycerus.* *Ptilinus.* *Scarabæus.* *Copris.* *Attelabus.* *Dermestes.* *Byrrhus.* *Anthrenus* *Cistela.* *Peltis.* *Cucujus.* *Elater.* *Buprestis.* *Bruchus.* *Lampyris.* *Cicindela.* *Omalysus.* *Hydrophylus.* *Dyticus.* *Gyrinus.*
		II. . . . Or, four articulations to all the feet, such as the	*Melolontha.* *Prionus.* *Cerambix.* *Leptura.* *Stenocorus.* *Luperus.* *Cryptocephalus.* *Crioceris.* *Altica.* *Galeruca.* *Chrysomela.* *Milabris.* *Rhinomacer.* *Curculio.* *Bostrichus.* *Clerus.* *Anthribus.* *Scolytus.* *Cassida.* *Anaspis.*
		III. . . . Or, three articulations to all the feet, such as . .	*Coccinella.* *Tritoma.*
		IV. . . . Or, five articulations in the two first pair of feet, and four only in the hinder pair, such as	*Diaperis.* *Pyrochroa.* *Cantharis.* *Tenebrio.* *Mordella.* *Notoxus.* *Cerocoma.*
	II. . . . Or the shell is hard, and covers only part of the abdomen; and their feet have	I. . . . Either five articulations to all the feet	*Staphylinus.*
		II. . . . Or four articulations to all the feet	*Necydalis.*
		III. . . . Or three articulations to all the feet	*Forficula.*
		IV. . . . Or five articulations to the two first pair of feet, and four to the latter	*Meloe.*
	III. . . . The shell is soft, and their feet have	I. . . . Either five articulations to the two first pair of feet, and four only to the latter	*Blatta.*
		II. . . . Or two articulations to all the feet . . . . ,	*Trips.*
		III. . . . Or three articulations to all the feet	*Gryllus.* *Acrydium.*
		IV. . . . Or four articulations to all the feet	*Locusta.*
		V. . . . Or five articulations to all the feet	*Mantes.*

SECTIONS.	ARTICLES.	GENERA.
II. . . . Hemyptera, or insects whose upper wings are half crustaceous, half membranaceous		*Cicada.* *Cimex.* *Naucoris.* *Notonecta.* *Corixa.* *Hepa.* *Psylla.* *Aphis.* *Chermes.* *Coccus.*
III. . . . Insects with four farinaceous wings		*Papilio.* *Sphinx.* *Pterophorus.* *Phalæna.* *Tinæa.*
IV. . . . Insects with four naked membranaceous wings	I. . . . Three articulations to the feet .	*Libellula.* *Perla.*
	II. . . . Four articulations to the feet .	*Raphidia.*
	III. . . . Five articulations to the feet	*Ephemera.* *Phryganea.* *Hemerobius.* *Formicaleo.* *Panorpa.* *Crabro.* *Urocerus.* *Tenthredo.* *Cynips* *Diplolepis.* *Eulophus.* *Ichneumon.* *Vespa.* *Apis.* *Formica.*
V. . . . Insects with two wings		*Oestrus.* *Tabanus.* *Asilus.* *Stratiomys.* *Musca.* *Stomoxys.* *Volucella.* *Nemotelus.* *Scatopse* *Hyppobosca.* *Tipula.* *Bibio.* *Culex.*
VI. . . . Insects without wings		*Pediculus.* *Podura.* *Forbicina.* *Pulex* *Chelifer.* *Acarus.* *Phalangium.* *Aranea.* *Monoculus.* *Binoculus.* *Cancer.* *Oniscus.* *Asellus.* *Scolopendra.* *Iulus.*

able VIII. *A methodical Division of Worms.*

WORMS ARE

			GENUS.
Section I. Naked worms			1. Gordius. 2. Lumbricus. 3. Ascarides. 4. Sanguisuga. 5. Limax. 6. Tænia.
Section II. Covered worms.	Order I. With univalve shells.		1. Patella. 2. Haliotis. 3. Tubulus. 4. Nautilus. 5. Cochlea. 6. Nerites. 7. Trochus. 8. Cilindrus. 9. Voluta. 10. Strombis. 11. Buccinum. 12. Murex. 13. Purpura. 14. Porcellana. 15. Globus.
	Order II. With bivalve shells.		1. Ostrea. 2. Chama. 3. Concha cordis. 4. Pecten. 5. Mytulus. 6. Solen.
	Order III. With polyvalve shells.		1. Pholas. 2. Balanus. 3. Concha Anatifera. 4. Chiton.
Section III. Crustaceous worms.			1. Asterias. 2. Echinus.
Section IV. Polypi,	Order I. Naked polypi.		1. Hydra. 2. Urtica Marina.
	Order II. Polypi, in corneous or ligneous cells.		1. Lithophyton. 2. Corallina.
	Order III. Polypi in cretaceous cells.		1. Corallium. 2. Madrepore.
	Order IV. Polypi in soft and spongy cells.		1. Eschara. 2. Spongia. 3. Alcyonium.